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HIGH REPETITION RATE SEQUENCE PULSE Nd:YAG LASER

40080041 Tianjin TIANJIN DAXUE XUEBAO [JOURNAL OF TIANJIN UNIVERSITY] in Chinese No 1, Jan 87, pp 109-114

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[Text] Abstract. This paper gives analysis and experiments introducing a high repetition rate sequence pulse Nd:YAG laser. The shortest optical pulse separation produced by this experimental apparatus was less than 2μs. [Keywords: High rate pulse laser, solid state laser]

1. Introduction

Since 1976 we have employed longitudinal electric field KDP crystals as high repetition rate Q switches to fabricate sequence pulse ruby lasers(1), and in successive applications in areas of high-speed photography and coherent metering. Now, due to the application requirements of scattered spot correlation testing of high-speed flow fields, we plan to develop this avenue of experimental research work. Because Nd:YAG belongs to a four energy level system, there are important distinctions between its operational requirements and a corresponding sequence pulse ruby laser. The theoretical analysis and experimental results provided by this paper are in agreement. Subsequently, the basis for the design of the laser and automatic control optimized operation is provided.

2. Experimental Apparatus

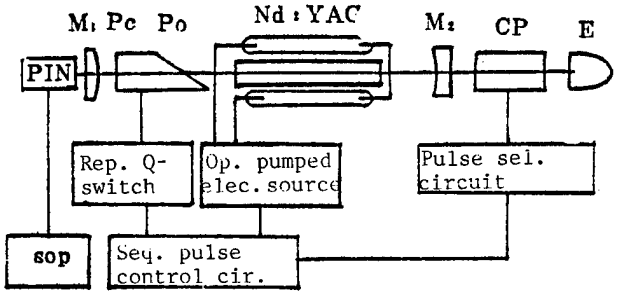

Fig. 1

The experimental apparatus is as shown in Fig. 1. This paper discusses only the pulse reflection (PRM) output coupling system. The specially designed convex mirror M_1 and the concave mirror M_2 form a natural aperture selected mode state stable harmonic cavity (to be introduced in a separate paper). The Nd:YAG beam, 6 X 100mm, is a medium quality pulse operating beam. The pulse X_e lamp is 9.5 X 100mm. The Nd:YAG alone is liquid cooled using a 0.5 percent potassium chromate solution and a double layered optical filter with an ultraviolet filter coating of the Institute of Chemistry, CAS. The reflectivity of mirrors M_1 and M_2 are 99 percent and 40 percent respectively. Pc is a (Pukeer [2528 0344 1422]) box permitting the refractivity to match the solution, its window is single sided? and antireflecting, and Po is a media film polarized plate. CP is the pulse selection apparatus, E is an energy meter, and PIN is a photo diode and a 10MHz memory oscilloscope detection output pulse. The high voltage pulse of the repetition Q switch leading edge is 10ns, the trailing edge is < 1μs, and the repetition rate is 20KHz to 1MHz with 1 to 99 pulses in steps of 1. The sequence pulse generator serving as the controller uses a 5MHz crystal oscillator circuit and all the operating parameters can be reliably preset in steps of 1μs. The maximum electrical capacitance of the pump voltage source is 700μf and the fluctuation of the pump optical wave shape is 10 percent.

3. Operation Analysis

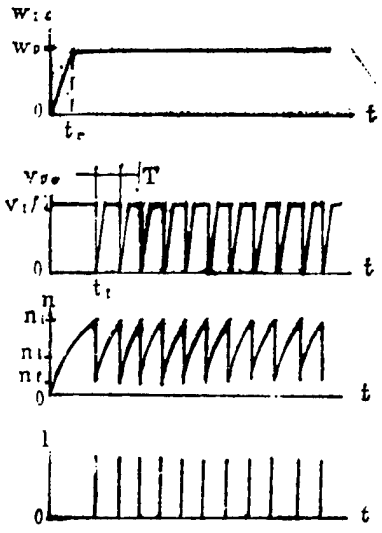

Fig. 2

The operational principle of the laser is shown in Fig. 2. For conditions of single ordered quasi continuous pumping, an entirely finite stable sequence pulse is output. The conditions for attaining steady state optimal operation are: (1) uniform speed pumping, i.e. the optical pumping speed function W_{14} must have an extremely small wave motion and sufficiently long flat top portion. (2) If entry into steady state operation is desired beginning from the

first pulse, it must correspond to an appropriate delay, t_1, and it is required that $t_1 \geq t_r$, t_r is the equivalent linearized rise time of W_{14}. (3) Corresponding to a fixed pulse repetition frequency there must be a sufficiently strong pumping speed, W_p. The above relationships can all be well described through the solutions of the macroscopic speed equations of the laser. Here the energy level lifetime of Nd:YAG can be considered to be $\tau_{43} = 0$. And $\tau_{21} =$ 30ns (2), consequently, even when seeking μs magnitude pulse separation high speed sequence pulse lasers we can put $\tau_{21} = 0$, whereupon the speed equations can be written

$$\frac{dn}{dt} = W_{14}(t)(N-n) - \frac{\sigma_{32}}{h\nu_{32}} nI \tag{1}$$

$$\frac{dI}{dt} = c\sigma_{32} n \frac{l}{L} I - \frac{I}{\tau_c} \tag{2}$$

in which n is the number of reflected particles; N is total number of particles; I is the intensity of light in the cavity; c is the seep of light; l and L are lengths of the activation medium and the optical cavity respectively, σ_{32} is the cross section receiving laser radiation; τ_c is the lifetime of cavity photons, which is a function of the absorption dissipation of the insertion components within the cavity, the refractivity, R_1 and R_2 of the cavity mirrors, the cavity diffraction dissipation (considered to be concentrated at the cavity mirrors and also including the mirror absorption and scattering dissipation) ε_1 and ε_2. τ_c can be written as

$$\tau_c = 2L/(c\{\delta - ln[(R_1 - \varepsilon_1)(R_2 - \varepsilon_2)]\}) \tag{3}$$

threshold particle number

$$n_t = (\tau_c c \sigma_{32})^{-1} \tag{4}$$

The high Q portion in a sequence pulse period forms a Q switch pulse output which is the same as discussion and results of a single ordered Q switch. At this time, omitting the W_{14} term of formula (1) and solving (1) and (2) simultaneously we get

$$I(t) = ch\nu_{32} \frac{l}{L} \left\{ n_t ln \left| \frac{n(t)}{n_i} \right| + n_i - n(t) \right\}$$

where $N(t) = n_t$, $I(t) = I_{max}$ (5)

pulse width(2) $\Delta t_p = \tau_c \frac{n_i - n_f}{n_i - n_t[1 + ln(n_i/n_t)]}$

Even more important for the operational analysis of a sequence pulse laser is discussion of the low Q portion of its period. For this reason we will discuss in detail equation (1). We refer to the reflection level, n_i/n_t, the threshold, n_t, the pump speed steady state value, W_F, the pulse period, T, and the delay, t_1, as the operating parameters of the laser. For convenience, we simplify $W_{14}(t)$ as a linear rising trapezoidal function. The solution of equation (1) in this form has the following conditions:

(1) If all the output sequence pulses appear in the linear increasing section of $t_1 < t_r$, then for the ith pulse the solution of (1) is

$$\ln\frac{N-n_{f(i-1)}}{N-n_i}=\frac{W_F}{2t_r}Tt_1+\frac{W_P}{2t_r}(i-1)T^2 \tag{6}$$

$$n_f=\begin{cases} n_{f(i-1)}, & i\neq 1 \\ 0, & i=1 \end{cases}, \quad (i=1,2,3\cdots)$$

in which n_f is the number of reflections remaining in the activation medium after the Q switch pulse emits. It can be obtained from (5) when making $I_{max} = 0$:

$$n_f=n_i+n_t\ln\frac{n_t}{n_i} \tag{7}$$

(2) For $t_1 \geq t_r$, the solution of equation (1) for the first pulse is

$$\ln\frac{N}{N-n_1}=W_F\left(t_1-\frac{1}{2}t_r\right) \tag{8}$$

and for any ith pulse when $t_1 \geq t_r$, the solution of equation (1) is

$$\ln\frac{N-n_{f(i-1)}}{N-n_i}=W_PT \quad (i=2,3,4\cdots)$$

When steady state (W_p = a constant), this is written as

$$\ln\frac{N-n_f}{N-n}=W_PT \tag{9}$$

(3) Convergence of the system; that is, if due to an imprecision of t_1 or W_p or n_t has an instantaneous fluctuation, the question of whether or not the behavior of the system is emissive. The fluctuation above causes n_j to deviate from the given steady state value by a Δn_i consequently making the corresponding n_{fi} have a deviation of Δn_{fi} which in turn leads to a Δn_{i+i}. This cyclical process can be written as

$$\Delta n_{i+1}=\frac{\Delta n_{i+1}}{\Delta n_{fi}}\cdot\frac{\Delta n_{fi}}{\Delta n_i}\cdot\Delta n_i$$

whereupon from formulae (9) and (7) we can calculate the deviation described above after going through one T

$$\Delta n_{i+1} = \frac{N - n_{i+1}}{N - n_{fi}} \left(1 - \frac{n_f}{n_i}\right) \Delta n_i \qquad (10)$$

$$= \Gamma \cdot \Delta n_i$$

This result shows that $\Gamma < 1$, and so proves that the operation of this sequence pulse laser system is convergent or that the system is self-sustaining stable. Also the higher the operation level (n_i/n_t large) the larger $|\Gamma|$, and the faster it converges. This conclusion has been verified by a large quantity of experimental data.

(4) Pump source design and operating parameter selection. Wanting to be able to operate normally for a period, T, corresponding to a fixed n_i/n_t level, we must ensure a corresponding W_p. It, in turn, is attained by the links through electrical energy, U_E, of the stored energy net work for the X_e lamp discharge, conversion efficiency K, becoming the optical energy, U_R, of the excitation Nd:YAG beam.

$$U_R = \frac{dn}{dt} h\nu_{41} V_R t_L = W_P (N - n) h\nu_{41} V_R t_L$$

$$t_L \approx 2mR_{\Sigma} c_i \qquad (11)$$

and $U_E = K^{-1} U_R$ so the initial value of the lamp discharge voltage is

$$V = \left(\frac{2U_R}{mc_i K}\right)^{1/2} \qquad (12)$$

V_R is the activation volume of the Nd:YAG beam, t_L is the lamp's flash time, i.e., the effective width of $W_{14}(t)$, K_p is the equivalent average discharge resistance, m and c_i are respectively the section number and single section capacitance of the simulation network. The value for K of reference (2), confirmed by experiments, is the product of K_1, K_2, and K_3. K_1 is the efficiency factor from electrical energy to the X_e lamp's optical energy and can be taken as 0.5; K_2 is the efficiency factor of the condenser which is taken as 0.5; and K_3 is the ratio of YAG beam absorbed X_e lamp pumped light, taken as 0.10 so $K \simeq 0.025$. From formulae (12), (11), and (9) we know

$$V \propto 1/\sqrt{T} \qquad (13)$$

The laser output pulse energy each pulse period is

$$u_p \doteq \frac{\ln(1/R_1 R_2)}{\ln(1/R_1 R_2) + \Delta_i} h\nu_{32} (n_i - n_f) V_R \qquad (14)$$

in which $\Delta = \delta + \varepsilon$ is the other cavity dissipation apart from cavity mirror transmission dissipation. From experiments, u_F is measured from which formula (14) can compute n_i. Comparing this with the operation level n_i/n_t

assumed for the theoretical computations and making revisions we can determine the appropriate component parameters and operating parameters for a fixed system which can then provide the basis for automatic control operation.

Analyzing the above results, the conditions for number (1) are subordinate to formula (6) so it can be proved that regardless of the value taken for t_1, there will be no result where n_i = a constant. Consequently, from formula (5) we know that I_m also cannot be a constant and at most there can only appear continuous situations with two pulses being equal strength. Therefore, a sequence pulse laser operating at the W_{14} rising section is unable to work stablely. Figure 3 is an experimental oscilloscope photograph of a sequence pulse output working under these conditions with T = 4μs, t_1 = 100μs, $(t_1 + 99T) < t_r$. Consequently, in situations with common multiple sections, large capacitance simulation networks ($t_r \approx 500\mu s$), seeking short pulse separation operation require strong pumping, whereupon t_1 is smaller so it is difficult to escape a situation where the large amplitude output fluctuates. But for a three energy state ruby laser, because the necessary t_1 is larger, usually the energy satisfies $t \geq t_r$ and this difficulty does not exist. This is the outstanding difference between the operation of these two systems.

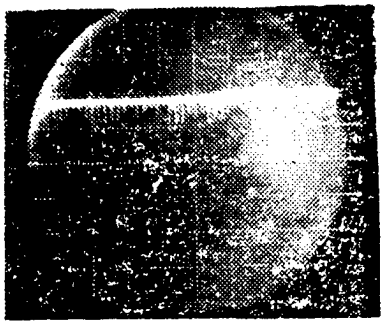

Fig. 3 20μs/div

For number (2) type conditions, because equations (8) and (9) are unrelated to the pulse sequence number i, simultaneous solution of formulae (8), (9), and (7) only require us to make $n_1 = n_2 = n_3$ so it can be solved to get $t_1 = f(n_i, n^t)$, when N, W_p, T, t_r, and n_t all have precise assigned values, t_1 and n_i correspond one to one. Because this system is also self sustaining stable, we only need satisfy $t_1 \geq t_r$ and generally good, stable operation can be attained.

4. Experimental Results

The above discussion gives us possible avenues to seek stable operation of a Nd:YAG sequence pulse laser. They are:

1. Since $t_r \sim R_F c_i$, therefore we use the method of reduced c_i to satisfy the requirement of $t_1 \geq t_r$, as for example in our system, where for T = 4μs, operation of t_1 = 100μs, the complementary value of c_i used is about 20μf. This ought to be the most standard method. For situations of small pulse separation and a large number of pulses are also not desired, a single stage small capacitance discharge mode can also be applied, using the flat portion which exceeds the threshold pumping speed and operating there. This can produce a short sequence output with not very large amplitude deviation. The photograph in Fig. 4 is this situation. Here T = sμs and the first pulse in the figure is disagreeably large which is easily resolved by reducing t_1. Figure 5 is a single pulse photograph. The trailing edge shown in the figure illustrates that the oscilloscope response of a 10MHz bandwidth is not enough and actual bandwidth ought to be < 30ns.

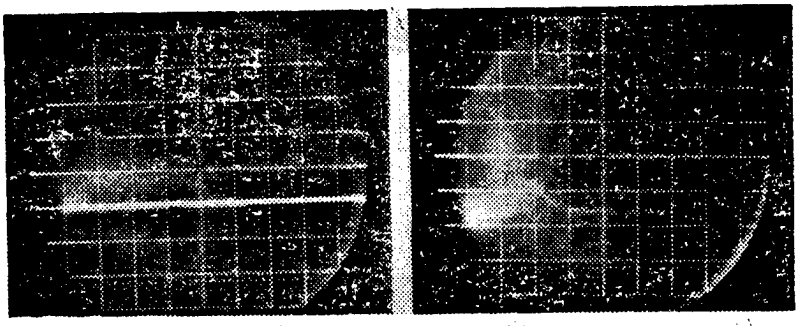

Fig. 4 20μs/div

Fig. 5 50μs/div

2. For pumping with a larger t_r value, make the Q switch and the pulse gating apparatus CP be used together. When the rising edge of $W_{14}(t)$ is about to conclude, introduce Q switch operation, sacrifice the rising interval and allow its free oscillation. At the same time, the pulse selection apparatus outside the cavity executes gating. Experimental results using this technique are shown in Fig. 6 and Fig. 7 and the repetion and stability are quite good. The broken line in Fig. 6 represents the theoretical curve determined by formula (13). The larger deviation after T ≤ 3μs is caused by the 0.8μs trailing edge of our Q switch. Figure 7 is the relationship between output pulse energy (average value) and pulse separation, T, for a fixed pumping voltage (and thus fixed W_F). The broken line represents the theoretical curve determined from (9) and (14) while the short lines are the experiment distribution values. The fluctuations near 20μs and 28μs made by the optimal points present in the output coupling. The downward deviation of u_p for ≤ 3μs is due to the same cause as in Fig. 6. Consequently, our experiment and the theoretical analysis given in this paper are in agreement which proves that the theoretical results of the paper are applicable.

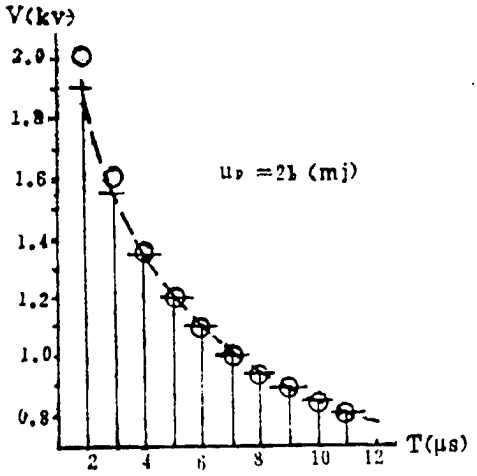

Fig. 6

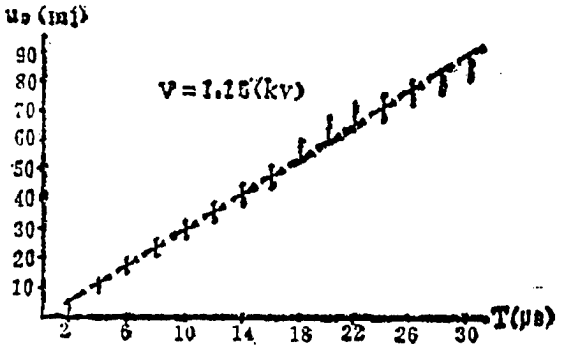

Fig. 7

This work was a part of a grant for scattered spot correlation testing of high velocity flow fields directed by professor Shu Wei [5289 0251]. When discussing methods, we received encouragement and inspiration from him and from Lu Yangsheng [0712 2254 3932]. Li Xifu [2621 0823 4395] and Li Xiyuan [7812 1311 3293] provided much assistance with the experimental work for which we express our deep gratitude.

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TWO-DIMENSIONAL NUMERICAL SIMULATION OF FORMING OF SELF-FORGING FRAGMENT

40080092 Beijing JISUAN WULI [CHINESE JOURNAL OF COMPUTATIONAL PHYSICS] in Chinese Vol 3 No 1, Mar 86 pp 77-85

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[Text] Abstract: Self-forging fragment charges (abbreviated as SFF) are a new kind of anti-tank charge derived from focused energy armour-destroying charges. To describe the formation process of SFF, we adopted two dimensional axially symmetric elastic--ideal plasticity--fluid dynamic equations. The basic numerical method used the loop integration method of M.L. Wilkins and the Lagrange quadrilateral grid. The formation process of a complete SFF obtained with the numerical simulation tallied fundamentally with high-speed X-ray photographs made during experiments. Certain methods in the numerical simulation simplified computations, saving machine time.

I. Introduction

Self-forging fragment charges (called SFF for short) are a new kind of anti-tank charge structure derived from focused energy armour-destroying charges. The "blast height" can attain a maximum of a thousand times the charge diameter and is able to pierce with great effect armour plating [from] within several dozen meters to as much as 100 meters [away]. Consequently, SFF have been emphasized widely by various countries.

Before the seventies, research on SFF primarily stressed experiments. Subsequently, the U.S., Sweden, and many other countries have done massive research work on SFF numerical computations. Beginning in 1974, articles on SFF were presented at the annual meeting of the International Symposium on Ballistics as seen in references [1] and [2].

A schematic of SFF is shown in Fig. 1.

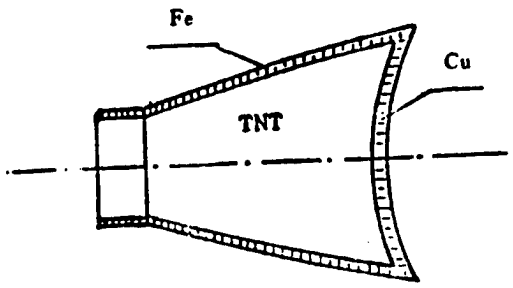

Fig. 1.

The SFF formation mechanism is as follows: After ignition of the installed explosive, the explosion detonation wave propagates in the primary explosion direction and acts on the metallic copper "explosive-shaping mask" making the explosive-shaping mask produce large plastic or fluid deformations, reversing, and accelerating motions. In the process of deformation, the explosive-shaping mask automatically forges a dense, high-speed pellet which is emitted and strikes the target.

The formation process of SFF is an extremely complex explosion problem and fluid elastic plasticity problem. With respect to its numerical simulation we can obtain various dynamic quantities from SFF in the process of formation (i.e., position, velocity, pressure, density, stress, and strain), detailed spatial and temporal distribution, and research the interaction and dynamic motion rules between the explosion detonation wave and the metallic explosive-shaping mask to clarify the dynamic mechanism of SFF formation. This enables us to find the optimum design parameters of an explosive-shaping mask.

II. Differential Equation System and Fixed Solution Conditions

Due to the axial symmetry of self-forging fragments, the formation process of SFF is an axially symmetric two-dimensional fluid elastic plasticity problem. For x axial symmetry, in x·r coordinates, the two-dimensional elastic--ideal plasticity--fluid dynamic equation system which describes SFF formation are:

Mass Conservation

$$\rho\frac{\partial(\frac{1}{\rho})}{\partial t}=\frac{\partial u_x}{\partial x}+\frac{\partial u_r}{\partial r}+\frac{u_r}{r} \tag{2.1}$$

Momentum Conservation

$$\rho\frac{\partial u_x}{\partial t}=-\frac{\partial(p+q)}{\partial x}+\frac{\partial s_x}{\partial x}+\frac{\partial \tau_{xr}}{\partial r}+\frac{\tau_{xr}}{r} \tag{2.2}$$

$$\rho\frac{\partial u_r}{\partial t}=-\frac{\partial(p+q)}{\partial r}+\frac{\partial \tau_{xr}}{\partial x}+\frac{\partial s_r}{\partial r}+\frac{s_r-s_\theta}{r} \tag{2.3}$$

$$u_x = \frac{\partial x}{\partial t} \tag{2.4}$$

$$u_r = \frac{\partial r}{\partial t} \tag{2.5}$$

Energy Conservation

$$\frac{\partial e}{\partial t} = -(p+q)\frac{\partial}{\partial t}\left(\frac{1}{\rho}\right) + \frac{1}{\rho}\left(s_x\frac{\partial \varepsilon_x}{\partial t} + s_r\frac{\partial \varepsilon_r}{\partial t} + s_\theta\frac{\partial \varepsilon_\theta}{\partial t} + \tau_{xr}\frac{\partial \varepsilon_{xr}}{\partial t}\right) \tag{2.6}$$

State Equation

$$P = p(\eta, e) \tag{2.7}$$

Where $\eta = \rho/\rho 0$ is the compression ratio.

Artificial Viscosity

$$q = \begin{cases} (C_1 C + C_2 L_r |\dot{\varepsilon}_r|)\rho L_r |\dot{\varepsilon}_r| & \dot{\varepsilon}_r < 0 \\ 0 & \dot{\varepsilon}_r \geq 0 \end{cases} \tag{2.8}$$

Strain Rate Formulae

$$\frac{\partial \varepsilon_x}{\partial t} = \frac{\partial u_x}{\partial x} \qquad \frac{\partial \varepsilon_r}{\partial t} = \frac{\partial u_r}{\partial r}$$

$$\frac{\partial \varepsilon_\theta}{\partial t} = \frac{ur}{r} \qquad \frac{\partial \varepsilon_{xr}}{\partial t} = \frac{\partial u_r}{\partial x} + \frac{\partial u_x}{\partial r} \tag{2.9}$$

Constitutive Equations

Within the plasticity extremes, the stress and strain of a material satisfies Hooke's law

$$\frac{\partial s_x}{\partial t} = 2\mu\left(\frac{\partial \varepsilon_x}{\partial t} - \frac{\rho}{3}\frac{\partial}{\partial t}\left(\frac{1}{\rho}\right)\right) + \delta_x$$

$$\frac{\partial s_r}{\partial t} = 2\mu\left(\frac{\partial \varepsilon_r}{\partial t} - \frac{\rho}{3}\frac{\partial}{\partial t}\left(\frac{1}{\rho}\right)\right) + \delta_r$$

$$\frac{\partial s_\theta}{\partial t} = 2\mu\left(\frac{\partial \varepsilon_\theta}{\partial t} - \frac{\rho}{3}\frac{\partial}{\partial t}\left(\frac{1}{\rho}\right)\right) \tag{2.10}$$

$$\frac{\partial \tau_{xr}}{\partial t} = \mu\frac{\partial \varepsilon_{xr}}{\partial t} + \delta_{xr}$$

When the stress of a material reaches the plasticity extreme, the Von Mises yield assumption is satisfied.

$$(s_1^2 + s_2^2 + s_3^2) - \frac{2}{3}\tau_0^2 \leq 0 \tag{2.11}$$

This is to say, if continuously loaded the partial quantities of the stress of the material will not increase further and the material mass conglomerate produces plastic deformation which cannot be restored. At this time, if the material mass conglomerate can resist the loading, its stress and strain relations will continue to follow Hooke's law.

When the pressure of the material's mass conglomerate, $P >> Y_0$, the deformation and motion of the material displays fluid characteristics.

Fixed Solution Conditions

(1) Initial conditions: In the total equation system (2.1) - (2.11), since the state equation is an algebraic equation, of the elastic constitutive equations only four are independent. Consequently, the initial conditions of the total equations solution only need provide the following initial values:

$$u_x=u_x^0,\ u_r=u_r^0,\ \rho=\rho^0,\ e=e^0$$
$$s_x=s_x^0,\ s_r=s_r^0,\ s_\theta=s_\theta^0,\ \tau_{xr}=\tau_{xr}^0,$$

(2) Boundary conditions: There are the following forms.

(i) Free plane boundary condition. The left end of the explosive zone, the outer boundary of the steel bright, and the outer boundary of the copper explosive-shaping mask are all free planes. On free planes the normal pressure, P_n is zero.

(ii) Pressure boundary condition. In computations after discarding the steel bright and the explosive, separately at the boundaries between the explosive and the steel bright and between the copper explosive-shaping mask and the explosive give the normal pressure value P_n.

(iii) Symmetrical axis boundary condition. On the symmetric axis, the normal velocity is zero and the shear stress is zero.

(3) Glide plane conditions. The boundary between the explosive and the steel bright is a glide plane. We assume that a glide plane is a completely smooth physical plane, i.e. on the glide plane there is no friction and viscosity. On the glide plane the normal velocity is continuous, the tangential velocity is interrupted, the normal stress is continuous, and the tangential stress is zero.

III. Some Questions in Computational Methods

There are various different methods for setting up a total difference scheme for equations (2.1) to (2.11). Here we use the loop integration type difference scheme of M.L. Wilkins (3) and the Lagrange quadrilateral grid method.

(3.1) Due to the gliding phenomena produced by action of contact explosion and high speed collision, a large distortion will occur in the gride of the boundary between two different masses. For this reason, the glide plane must be processed specially.

In the x·r coordinates, the glide plane is a curve changing with time and the superscripts + and - are used to represent respectively the physical quantities of the two sides of the glide line. The tangential velocities of the two sides are u_τ^+ and u_τ^-. The normal velocities are u_n^+ and $u_n^- = u_n$. From the momentum conservation equations and the glide plane conditions we can get the glide motion equation system.(4)

$$\frac{\partial u_\tau^\pm}{\partial t} - u_n\left(\frac{\partial u_n}{\partial s} - \frac{u_\tau^\pm}{R}\right) = \frac{1}{\rho^\pm}\left((\nabla\sigma)^\pm \cdot \vec{\tau}\right)$$
$$(u_\tau^+ - u_\tau^-)\left(\frac{\partial u_n}{\partial s} - \frac{1}{R}(u_\tau^+ + u_\tau^-)\right) = \frac{1}{\rho^+}\left((\nabla\sigma)^+ \cdot \vec{n}\right) - \frac{1}{\rho^-}\left((\nabla\sigma)^- \cdot \vec{n}\right) \qquad (3.1)$$

in which

$$\frac{\partial}{\partial s} = \cos\alpha\frac{\partial}{\partial x} + \sin\alpha\frac{\partial}{\partial r}$$
$$\sigma_i = s_i - P \qquad i = x, r, \theta$$

$\vec{\tau}$ = (cosα, sinα), $\vec{n}$ = (-sinα, cosα) are unit tangential and normal vectors at a certain point on the glide line. R is the local instantaneous radius of curvature at this point on the glide line, $|\partial s/\partial\alpha|$.

This way, although the tangential velocities on the glide line are separated as the two velocities u_τ^+ and u_τ^-, the motion equations at this time are also increased from two to three so the total equation system is still closed.

For the computation of the glide plane we used the "primary-secondary plane" method where one side is assumed primary and the other secondary. A secondary plane point attaches to the primary plane and glides on the primary plane.

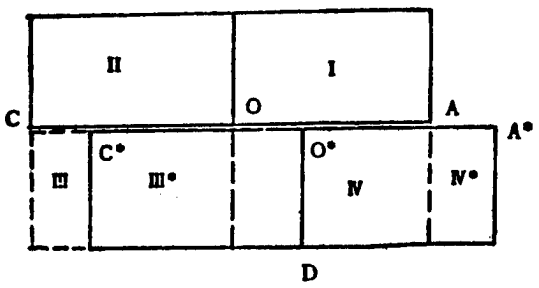

Fig. 2.

In Fig. 2, $\overline{AOC}$ represents a glide line above which is the primary plane, represented by A, O, C, and below is the secondary plane, represented by A*, O*, C*, with O* representing the point on the secondary plane nearest to O. The grid for the side of the primary plane is I, II and for the secondary side III*, IV*.

The computation process of the glide line has the following three major steps:

i) Computing primary plane point 0.

In the virtual grids III, IV on the side of the secondary plane corresponding with the grids I, II (the grids represented by broken lines in Fig. 2), the various dynamic quantities are determined by interpolation of quantities in its real grids. The areas of the virtual grids are taken as

$$A_{\text{III}}=\frac{|\overline{OC}|}{|\overline{OC^*}|}A_{\text{III}}^*,\quad A_{\text{IV}}=\frac{|\overline{OA}|}{|\overline{OA^*}|}A_{\text{IV}}^*$$

Thus, by substituting the quantities of grids I, II, III, IV into the computation formulae for a general grid, the velocity and position of point 0 on the primary plane is obtained.

ii) Computing secondary plane point 0*

After the position of the primary plane point is determined, the position of the glide line is also determined so the normal velocity of the secondary plane point is also found. The tangential velocity of the secondary plane point is computed using the velocity formula of the glide's fixed wall boundary. Then this tangential velocity is used to compute the new position, $\tilde{0}^*$, of point 0*.

iii) Primary-secondary plane coupling

Since the $\tilde{0}^*$ computed from ii) generally does not lie on the glide line, to make primary-secondary coupling, we draw a perpendicular line to point D at the time t^{n+1} from point $\tilde{0}^*$. This perpendicular intersects $\overline{OA}$ or $\overline{OC}$ in a point which is made to be 0* for the time t^{n+1}. If this point falls on the line OA, then the normal velocity of 0* is determined by the interpolation formula:

$$(u_n)_{0^*}=(u_n)_0+\frac{|\overline{OO^*}|}{|OA|}((u_n)_A-(u_n)_0)$$

(If the point falls on OC the interpolation formula used is similar to that above.) Here the velocity of point 0* is

$$\vec{u}_{0^*}=(u_n)_{0^*}\vec{n}_0+(u_\tau)_{0^*}\vec{\tau}_0$$

Here $\vec{\tau}_0$ and $\vec{n}_0$ are the unit tangent and normal vectors of primary plane point 0.

(3.2) In the two-dimensional Lagrange numerical simulation of self forging fragments, a difference grid represents a material mass conglomerate. Under stress action, the material mass conglomerate experiences deformation while the grid undergoes distortion. When the distortion is severe, there is no way to continue the computations. In general, there are two methods to resolve this problem: One is to introduce new artificial viscosity or increase the grid's "hardness." Another method is to redivide the grid.

In order to simplify the computations we chose the method of redividing the grid. The essence of the method is in preserving the convexity of each grid and preventing grid intersections.

In each step of the computation, distinguish the geometrical shape of the quadrilaterals surrounding each grid point. If a quadrilateral changes from convex to concave (0451 in Fig. 3.) then carry out processing to degenerate the quadrilateral grid into triangular grids so as to preserve the grid's convexity.

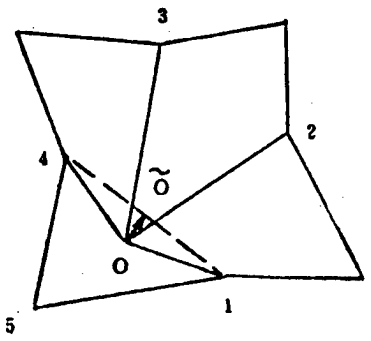

Fig. 3.

In Fig. 3, we first distinguished the four triangles surrounding point 0, $\Delta_{0,1,1+1}$ (1 =1, 2, 3, 4)). If

$$A_{0,1,1+1}=\frac{1}{2}(x_0(r_1-r_{1+1}) \quad +x_1(r_{1+1}-r_0)+x_{1+1}(r_0-r_1))<0$$

then the position of point 0 is adjusted to the new position $\tilde{0}(x_{\tilde{0}}, r_{\tilde{0}})$.

$$x_{\tilde{0}}=\frac{1}{|\overline{\Delta x}_{1+1,1}|^2}(x_0(\Delta x_{1+1,1})^2-\Delta x_{1+1,1}\Delta r_{1+1,1}\Delta r_{0,1+1}$$

$$+x_{1+1}(\Delta r_{1+1,1})^2)$$

$$r_{\tilde{0}}=\frac{1}{|\overline{\Delta x}_{1+1,1}|^2}(r_0(\Delta r_{1+1,1})^2-\Delta r_{1+1,1}\Delta x_{1+1,1}\Delta x_{0,1+1}$$

$$+r_{1+1}(\Delta x_{1+1,1})^2)$$

in which

$$\Delta x_{1+1,1}=x_1-x_{1+1},\ \Delta r_{1+1,1}=r_1-r_{1+1}$$

After the grid point position has been adjusted, the physical quantities of the four grids which neighbor it undergo adjustment based on mass, momentum, and energy conservation relations giving new physical quantities.

(3.3) In fluid dynamic two-dimensional computations with the premise of ensura fixed degree of precision, a vital question is how to reduce computation time. We believe that, apart from requiring a good computer, an effective method to reduce computation time is the adoption of measures corresponding with the conditions of concrete physical models.

The explosive-shaping mask of a self-forging fragment under the action of detonation waves deforms, propagates, and at the same time accelerates its motion. After it moves to the point of leaving the steel bright, the explosive detonation products fly out freely from the apparatus along the gaps between the steel bright and the mask. The steel bright does not offer much action in restraining the detonation products. At this time, in order to reduce computation time, we can dispense with the steel bright. That is, in the SFF numerical model, the SFF is only considered to be the explosive--explosive-shaping mask system.

After dispensing with the steel bright, in order to simulate the restraining action of the steel bright, at the outer boundary of the explosive and the mask the following pressure function is given as the pressure boundary condition.

$$P(x,r,t)\,|\,\text{external} = P(x,r,t_1)\exp(-k_1(t-t_1))$$

in which t_1 is the time the steel bright is discarded, $P(x, r, t_1)$ is the pressure distribution at the boundary at time t_1, and k_1 is a parameter to be determined.

K_1 may be obtained using a fitting method with pressure values of the detonation outer layer grid a few instants before discarding the steel bright.

Using methods the same as above, when the pressure of explosive detonation products falls to several hundred atmospheres and gradually tends to equilibrium, we drop the explosive zone and provide the pressure function at the boundary of the mask and explosive to serve as the pressure boundary condition.

For general conditions, the above process reduces computations of the grid about 90 percent, a vast saving of computation time. In addition to this we also adopt other measures. For example, in the detonation wave propagation interval, only for the grids where the detonation wave has reached have the dynamic quantities changed so we just compute these grids and the others remain in the initial static state and computations are not performed. In addition, in the later period of explosive-shaping mask formation (see Fig. 5), the tail surface grid distortion of the mask is severe and the computations require very small time steps making it impossible for the computations to proceed. At this time we just throw out a few of the tail surface grids. Of course, after throwing out these grids, the mask mass will maintain over 95 percent of the original apparatus mass.

IV. Numerical Simulation and Experimental Verification

In this section we use an A-05 model (see Fig. 1) as example to illustrate the numerical simulation and experimental verification of a self-forging fragment.

The A-05 model computations show that when the explosive detonation wave propagates to the explosive-shaping mask, an explosive zone reflected shock wave and a shock wave simultaneously incident to the mask make the pressure at the central part of the mask boundary reach as high as 470,000 atmospheres. The pressure peaks of the edge portion are somewhat lower at about 350,000 to 380,000 atmospheres.

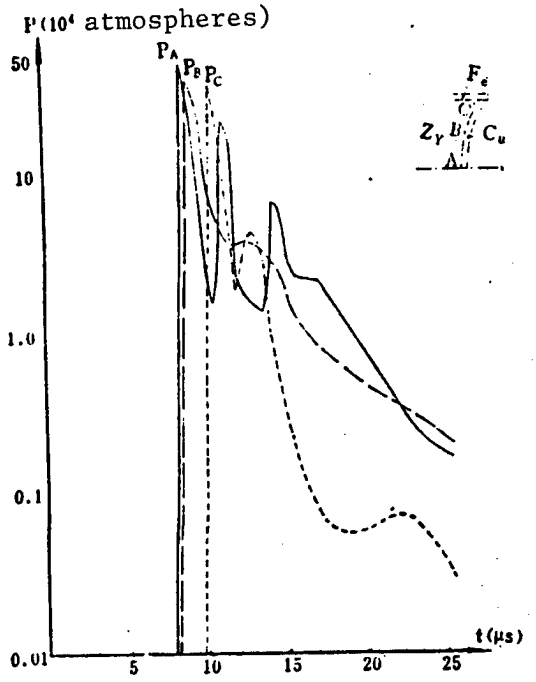

Fig. 4.

After the pressure of the explosive-shaping mask boundary has reached a peak value, it declines rapidly due to the action of Taylor waves. However, after the detonation wave reaches the steel bright, the reflected shock wave is propagated toward the mask, making it receive a second shock loading. At the same time, the reflected shock wave converges in the vicinity of the axis making it so the pressure of the mask boundary center can still reach 210,000 atmospheres.

Due to the arched boundary of the steel bright, the shock wave is reflected back and forth several times between the steel bright and the explosive zone. When the second reflected shock wave reaches the center portion of the mask boundary, it makes the mask receive a third shock loading forming a third pressure peak.

The explosive-shaping mask is precisely reversed under the action of the detonation wave. The multiple action of the shock wave deforms and accelerates motion. Due to the radial contraction extrusion of the edge portion and axial stretching of the central portion, the majority of the mass is concentrated in the vicinity of the central axis, the central portion becomes thicker, and the edge portion gets thin. After the velocity differences of the various parts of the explosive-shaping mask become small, the outer shape of the mask tends to stabilize.

Figure 5 shows the two-dimensional numerical simulation figure of the reflection shaping process of an A-05 model mask.

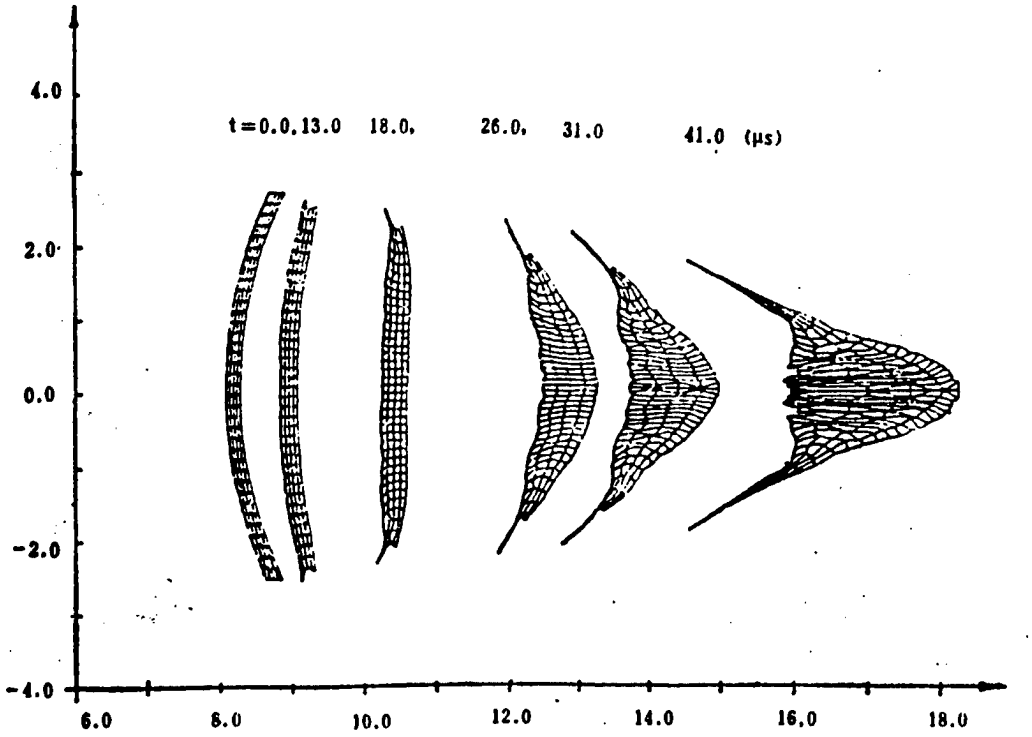

Fig. 5.

The computed figure basically matches pictures obtained during experiments with a strobe X-ray high-speed photography system. The one slight difference was that the experimental pictures showed a fracturing phenomena near the head of the explosive shaping mask's leading edge. The edges of these fragments were minutely turned outwards. In our computations, this sort of phenomena could not be reflected because breakage was not considered.

Figure 6 shows that the computed values of the axial positions of the explosive shaping mask leading edge agreed well with the experimental values.

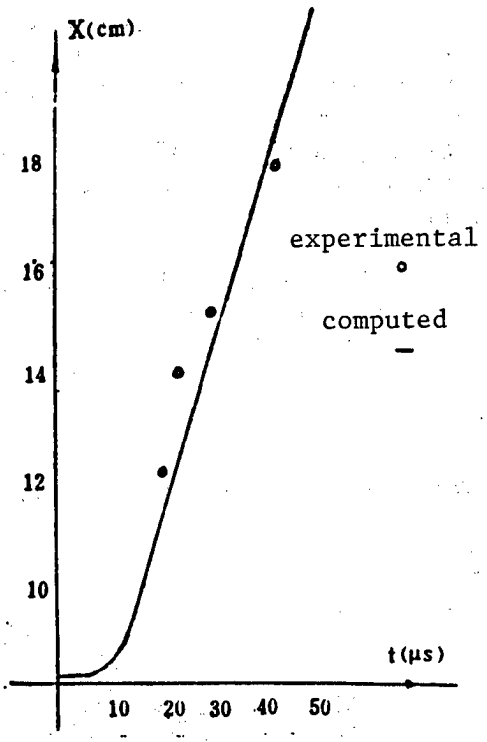

Fig. 6.

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SOLUTION OF EM WAVE LOSS THROUGH INHOMOGENEOUS AND LOSSY PLASMA-SHEATH USING FEM

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[Article by Liu Tiejun [0491 6993 6511] and Shi Zhongyue [4258 0022 1471] of Beijing Box 142, Sub-box 213, No 2. First paragraph is source abstract of article.]

[Text] This paper uses finite element methods to solve the problem of reflection and transmission of an electromagnetic wave passing through an arbitrarily dense cross section nonhomogeneous plasma sheath. The parameters of the sheath cross section are the horizontal flow parameters of a viscous shock wave layer for a typical reentry vehicle.(1) Using the virtual work principle and a linear interpolation function, the finite element equations are derived from the Helmholz equations. The sheath is divided by logarithmic dissection into 31 elements. Then, for frequencies of f = 400MHz, 4,000MHz, and 10GHz, the field values as well as reflection, transmission, and absorption coefficients were computed within the sheath. An estimate of the total power loss is also computed. Error analysis shows that the computational results are satisfactory. Compared with other methods, the finite element method provided in this paper is simple and direct yet precise. Therefore this method is appropriate for computing the wave loss for transmission through a plasma sheath with an arbitrary and even severely varying cross section.

I. Introduction

When ultra supersonic vehicles reenter the earth's atmosphere, in the space surrounding the vehicle, a strongly ionized, nonhomogeneous plasma layer is formed. This is what is commonly called a plasma sheath. The presence of this sheath creates severe reflection and absorption with respect to radio waves to the point that radio links between the vehicle and the surface of the earth are temporarily broken. This sort of interruption phenomena has always been a concern since under many conditions, especially in manned flights, it is necessary that the radio link with the earth be unbroken. In order to search for and study technological avenues to reduce interruption, it is necessary to compute precisely the losses at different transmission frequencies for each different configuration of the plasma sheath with respect to the antenna.

As is well known, the true mathematical description of a plasma sheath is rather complex. Consequently, when studying this question, most only count one or two major factors and make reasonable simplifications. However, even for the simplest one dimensional nonhomogeneous plasma lamina, it will lead to a second order ordinary differential equation with one varying coefficient. Further, this type of equation yields exact solutions only for a minority of cross sections with simple variations.(2)(3) Consequently we must find approximate solutions of the equation. One such type equation is the W.K.B. solution. However, this sort of method is appropriate only where the cross section variation relative to the wavelength of the propagated wave is a slowly changing function, i.e. the condition that $L/\lambda >> 1$, in which L is the spatial characteristic length of the problem under discussion and λ is the signal wavelength. Another way is the mapping method proposed by A. T. Villeneuve. In this method, the problem is mapped onto a similar problem which has an exact solution. This exact solution is then used to represent an approximate solution of the original problem. In fact, since the cross section variation of the sheath is not regular and nongradual, when the sheath thickness is approximately equal to the wavelength used, i.e. $L \simeq \lambda$, the above methods are both not ideal. In addition, from a consideration of the physics, if the plasma sheath is not homogeneous in one direction, the electromagentic wave components in this direction will no longer be plane waves. Based on the above factors, for the propagation problem of waves in a nonhomogeneous plasma sheath, the best thing is to use a numerical solution. However, since the problem to be solved is a mixed boundary value problem and the cross sectional variation is severe, if the finite difference method is used to solve this varying coefficient problem, it will lead to larger errors compared to the finite element method. For this reason, this paper will apply the finite element method to seek the solution of this type of problem.

Here we consider the condition where plane waves are incident perpendicularly. In order to perform discretization of the second order varying coefficient mixed boundary problem obtained from this condition and to give a numerical computational model, we begin from the virtual work principle and select a linear base function to derive the corresponding finite element equations. During computations, typical reentry vehicle viscous equilibrium flow field parameters are used. The distribution of the field within the sheath is computed respectively for operating frequencies of 400MHz, 4,000MHz, and 10GHz. Reflection coefficients, transmission coefficients, and attenuation coefficients are computed and the total power loss when these signals traverse the sheath are also provided. Lastly, an estimate of the computational error is done. The sheath profile is sectioned into 31 elements and the element lengths are dissected logarithmically. The computational results for the largest element length, $h_{max} = 0.016$cm, for the three frequencies mentioned above show that the relative errors of the total power loss are respectively 0.17 percent, 3 percent, and 9 percent.

II. Physical Model of a Plasma Sheath

Because a vehicle experiences atmospheric friction when reentering the earth's atmosphere, a portion of the vehicle's kinetic energy is converted into thermal energy causing certain electrons in the atmosphere to jump to higher bound

energy levels forming an excited state. Of these, some electrons are ionized completely away from the parent atoms and molecules. In this layer of non static, charge bearing, excited ionized gas created around the vehicle, a plasma sheath is formed.

The electromagnetic properties of a plasma sheath can be characterized using three frequency parameters: the plasma frequency, ω_p, the collision frequency, υ, and the cyclotron frequency, ω_c.(4) These parameters are determined by the reentry altitude, the aerodynamic properties of the vehicle, the reentry orbit, and the magnetic intensity.(5) Based on fluid dynamics and chemical dynamics we set up the corresponding Navier-Stokes system of equations. Solving this system of equations gives the electron density profile, N(z), and the collision frequency profile, $\upsilon(z)$, for the sheath. The reentry vehicle as considered in this paper is shown in Fig. 1. Computing the model of the flow field as viscous excited layers, it consisted of a thermochemical equilibrium model with seven components.(1) Consequently, the flow field parameters provided are rather accurate. The electron density profile, N(z), and collision frequency profile, $\upsilon(z)$, are as shown in Fig. 2 and Fig. 3.

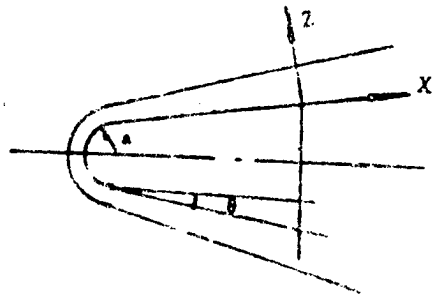

Fig. 1. Reentry vehicle schematic

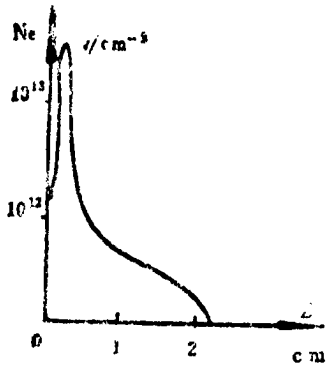

Fig. 2. Electron density profile

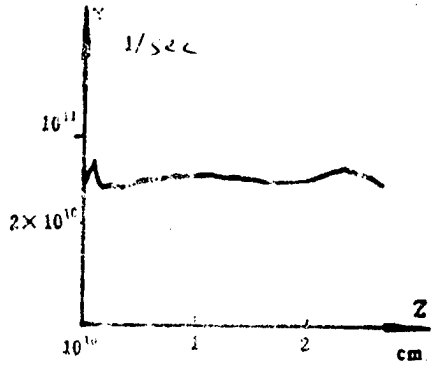

Fig. 3. Collision frequency profile

From geometric shaping considerations, the plasma sheath exhibits a round headed conical shape. However, we know that near the location of the antenna the radius of curvature of the two main curves are much larger than the wavelength so the plasma sheath in the vicinity of the antenna can be represented using an infinitely large plasma lamina.

Physically, the plasma sheath is actually a multiple constituent, time varying, non linear, and thermally as well as directionally hetromorphic medium lamina. To take all these factors into account, the mathematical model will become extremely complex to the degree that the problem cannot be solved. For this reason, based on actual conditions, only one or two major factors can be counted in establishing the mathematical model. For the different factors included, different models are obtained. In our model we made the following assumptions.

1. Single electron fluid assumption

We know that a real plasma sheath in addition to containing free electrons, ions, as well as atoms and molecules of oxygen, argon, etc., also contains ablation products. Supposing that under the effects of a high frequency electromagnetic field, non charge carrying neutral molecules, atoms, and heavy ions all are not in motion then only the light negative charge carrying free electrons move with the field and form electric currents. This way the multiple constituent plasma is viewed as a single electron fluid.

2. Time invariant medium assumption

The finite chemical reaction rate during the motion of the vehicle as well as disequilibrium make the sheath parameters vary with time. However, since the time for the electrical wave to go through the sheath is very short, to the point that in this brief interval the change of the sheath parameters is very small, the sheath can be seen as a time invariant medium.

3. One dimensional nonhomogeneous assumption

The parameters N and υ for a real sheath are functions of the spatial position. However, the variation along the two tangent lines of the wall is much smaller than the variation along the normal. Therefore, the sheath can be assumed to be a one dimensional nonhomogeneous plasma lamina.

4. Linear medium assumption

When the incident field is very strong, the electron density, N, is a function of the incident field strength.(6) This causes nonlinear effects and consequently nonlinear differential equations must be used to describe it. Here we assume that the incident field is weak and does not lead to this sort of nonlinear effect.

5. Cold plasma assumption

Real plasma sheaths are rather high temperature plasmas. In such plasmas, the pressure gradient within the plasma constitutes a restoring force. Subsequently, the waves within the plasma is increased, like the appearance of electro-acoustic waves.(7) Here we assume that the thermal velocity of the electrons is far less than the phase velocity of the electric wave. Hence it can be simplified as a cold plasma model.

6. Directional uniformity assumption

Under the effect of a magnetic field, the electrons in a plasma coil around the magnetic lines of force, making Laminar motion. Consequently, the plasma becomes electrically a nonuniform medium. Here we assume that inside the plasma, there is no artificial constant magnetic field and that the earth's magnetism is extremely minute. Therefore the plasma can be viewed as a directionally uniform medium. That is, the relative dielectric tensor $\varepsilon(z)$ degenerates into a scalar $\varepsilon(z)$.(8):

$$\varepsilon(z) = 1 - \frac{x}{1+z^2} - j\frac{xz}{1+z^2} \tag{1}$$

in which, x is the normalized plasma frequency $x = \omega_p^2/\omega^2$

z is the normalized collision frequency $z = \upsilon/\omega_0$

ω_p is the plasma frequency, $\omega_p^2(z) = N_0(z)e^2/m\varepsilon$

ω is the operating frequency, e, m being the electron charge and mass ω_0 is the dielectric constant of free space.

z is the thickness coordinate of the plasma sheath.

III. Mathematical Description of the Problem

Suppose two half infinite spaces where $z < 0$ and $z > d$ to be free space, denoted respectively as zone I and zone III. Let $0 < z < d$, be filled with a nonhomogeneous plasma along the z direction and be denoted as zone II. Let there be a TM plane wave of unit magnitude propagating in the positive z direction.

$$\vec{E} = \hat{i}\, e^{-jk_0 z} \tag{2}$$

is perpendicularly incident from zone I on to the boundary $z = 0$ as shown in Fig. 4. In the formula, $\hat{i}$ is a unit vector of the x axis, k_0 is the wave number in free space, $k_0 = 2\pi/\lambda_0$, and λ_0 is the wave length in free space. In the formula the time harmonic term $e^{j\omega t}$ is ignored.

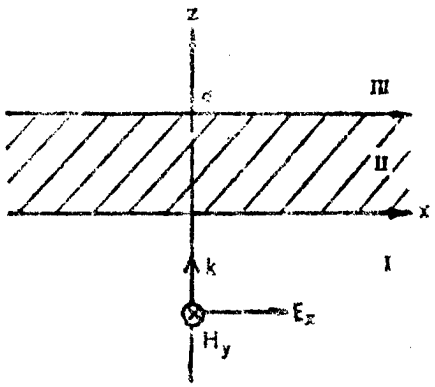

Fig. 4. Plasma lamina and incident TM wave

On the z = 0 boundary, the wave is partially reflected. The reflected wave is

$$\vec{E}' = \hat{i} R e^{j k_0 z} \tag{3}$$

in which R is the reflection coefficient of the field. There is also a portion of the wave which enters into the plasma. Since the plasma is homogeneous in the x and y directions, based on the electromagnetic field's kinematic boundary conditions, we know that the electric field is a function only of z. However, because the plasma is not homogeneous in the z direction, E(z) is no longer a plane wave. From Maxwell's equations

$$\frac{\partial E_x}{\partial z} = -j\omega\mu_0 H_y \tag{4}$$

$$\frac{\partial H_y}{\partial z} = -j\omega\varepsilon_0 \varepsilon(z) E_x \tag{5}$$

we can derive the wave motion equation satisfied by the electric field $E_z(z)$

$$\left(\frac{d^2}{dz^2} + k_0^2 \varepsilon(z) \right) E_x(z) = 0 \tag{6}$$

in which E_z and H_z are the intensities of the electric and magnetic fields in the plasma [Note: In the equalities derived below the subscripts for E_x and H_y are omitted.], ω is the operating frequency, and ε(z) is the plasma's relative dielectric constant given in formula (1). Based on the continuous boundary condition of the tangential component of the electric field at z = 0, we can get

$$1 + R = E(0) \tag{7}$$

Based on the continuous boundary condition of the tangential component of the magnetic field at z = 0 and considering formula (4), we have

$$-jk_0 + jk_0 R = -\left.\frac{dE}{dz}\right|_{z=0} = E'(0) \tag{8}$$

Substituting formula (7) into formula (8) the boundary condition at z = 0 is found to be

$$E'(0) - jk_0 E(0) + 2jk_0 = 0 \tag{9}$$

On the boundary z = d, the wave goes from within the plasma into zone III. In zone III the form of the transmitted wave is

$$E_1 = \widehat{T} e^{-jk_0(z-d)} \tag{10}$$

in which T is the transmissivity coefficient of the field. Based on the continuous boundary condition of the tangential component of the electric field, we have

$$E(d) = T \tag{11}$$

and, from the continuous condition of the tangential component of the magnetic field and consideration of formula (4), we have

$$\left.\frac{dE}{dz}\right|_{z=d} = -jk_0 T e^{-jk_0(z-d)}$$

whereupon the boundary condition at z = d is derived

$$E'(d) + jk_0 E(d) = 0 \tag{12}$$

This way the problem under discussion is summed up as a boundary value problem of single second order varying coefficient ordinary differential equations (6), (9), and (12).

IV. Derivation of the Galekin Finite Element Equations

Obviously, for the boundary value problem described in the previous section, the field function, E(z), on region $\overline{G}$ = [0.d], must satisfy the second order continuous differentiable smooth condition. In order to use the virtual work principle to derive the Galekin finite element equations, we define a single order Sobolev space, $H'_B(\overline{G})$ which satisfies boundary conditions (9) and (12).

$$H'_B(\overline{G}) = \{\varphi(z) | \varphi(z) \in L^2, \varphi'(z) \in L^2, \varphi(z) \text{ 满足边界条件 (9), (12)}; 0 \leqslant z \leqslant d\}$$

in which L^2 is square area function space. Clearly, $E(z) \in H'_B(\overline{G}) \cap C^2(\overline{G})$, in which $C^2(\overline{G})$, is a second order continuous differentiable function space on $\overline{G}$. Selecting the verification function $\varphi(z) \in H'_B(\overline{G})$, based on the virtual work principle we have

$$I=\int_0^d \left\{ \left[\frac{d^2}{dz^2}+k_0^2\in(z)\right] E(z) \right\} \varphi(z)dz=0 \tag{13}$$

Partially integrating the above formula we can get

$$I=E'(d)\varphi(d)-E'(0)\varphi(0)-\int_0^d E'(z)\varphi'(z)\,dz+\int_0^d k_0^2\in(z)E(z)\varphi(z)dz=0$$

and substituting in the boundary conditions (9) and (12) we have

$$I=\int_0^d [E'(z)\varphi'(z)-k_0^2\in(z)E(z)\varphi(z)]dz+jk_0E(d)\varphi(d)+jk_0E(0)\varphi(0)-2jk_0\varphi(0)=0 \tag{14}$$

This formula is the basic equation using the finite element method. Obviously, with respect to the smoothness requirement of E(z), this equation is lower than the differential equation (6). That is it requires E(z), $\varphi(z)\varepsilon H'_B(\overline{G})$.

The Galekin finite element method is to divide the [0.d] portion in an n dimensional Sobolev space into n-1 elements using n nodes $0 = z_1 \leq z_2 \ldots \leq z_n$ and constructing divided interpolation base functions on the n-1 elements. Then this linear assemblage of interpolation base functions is used to describe E(z) and $\phi(z)$. Since N(z) varies severely, logarithmic divisions are used. If the ith element is denoted as $e_i = [z_i, z_{i+1}]$ then the division of the region can be expressed as

$$[0.d] = \sum_{i=1}^{N-1} e_i \tag{15}$$

Consequently, formula (14) can be rewritten as

$$\sum_{i=1}^{i-N}\int_{e_i} [E'(z)\varphi'(z)-k_0^2\in(z)E(z)\varphi(z)]dz+jk_0E(d)\varphi(d)+jk_0E(0)\varphi(0)=2jk_0\varphi(0) \tag{16}$$

Denoting the field strength at node point j $E(z_i) = E_i$, i = 1,...N - 1, and within e_i selecting the linear functions $N_i(z)$, $M_i(z)$

$$N_i(z)=\frac{z_{i+1}-z}{L_i} \tag{17}$$

$$M_i(z)=\frac{z-z_i}{L_i} \tag{18}$$

in which $L_i = Z_{i+1} - Z_j$,

whereupon $VE(z) \varepsilon H'_B(\overline{G})$ and we have

$$E(z)=E_iN_i(z)+E_{i+1}M_i(z) \tag{19}$$

Make

$$[N] = [N_i(z), M_i(z)] \tag{20}$$

$$\{\delta\}_{e_i} = \begin{Bmatrix} E_i \\ E_{i+1} \end{Bmatrix} \tag{21}$$

$\{\delta\}_{e_i}$ is called the field strength vector of the element nodal point so formula (19) can be written as

$$E(z) = [N]\{\delta\}_{e_i} \tag{22}$$

Using the same interpolation base function, the weight function, $\phi(z)$, within e_i can be represented as

$$\varphi(z) = [N]\{\delta^*\}_{e_i} \tag{23}$$

From formula (19) the rate of change of the electric field strength within e_i can be obtained

$$E'(z) = \frac{dE(z)}{dz} = [B]\{\delta\}_{e_i} \tag{24}$$

in which

$$[B] = \begin{bmatrix} -\frac{1}{L_i}, & \frac{1}{L_i} \end{bmatrix} \tag{25}$$

Similarly we can get

$$\varphi'(z) = [B]\{\delta^*\}_{e_i} \tag{26}$$

In order to standardize each interpolated value, an affine transformation is introduced

$$\xi = \frac{z - z_i}{L_i} \tag{27}$$

Thus any region $[Z_i, Z_{i+1}] \rightarrow [0.1]$. Moreover

$$N_i(z) = 1 - \xi \tag{28}$$

$$M_i(z) = \xi \tag{29}$$

From formula (27) we have

$$z = z_i + \xi L_i \tag{30}$$

$$dz = L_i d\xi \tag{31}$$

$$[N(z)] = [1-\xi, \xi] \tag{32}$$

$$[L] = \frac{1}{L_i}[-1, 1] \tag{33}$$

By substituting formulae (22), (23), (24), and (26) into the first term of the left side of formula (16), we get

$$\begin{aligned} &\int_{e_i} [E'(z)\varphi'(z) - k_0^2 \in(z) E(z)\varphi(z)]\, dz \\ &= \{\delta^*\}^T_{e_i} \left(\int_0^1 \left\{ [B]^T[B] - k_0^2 \in (z_i + L_i\xi)[N]^T[N] \right\} L_i d\xi \right) \{\delta\}_{e_i} \end{aligned} \tag{34}$$

Make

$$[K]_{e_i} = \int_0^1 \left\{ [B]^T[B] - k_0^2 \in (z_i + L_i\xi)[N]^T[N] \right\} L_i d\xi \tag{35}$$

Calling this the element field strength coefficient array, substituting in formulae (32) and (33) we have

$$[K]_{e_i} = \begin{bmatrix} \frac{1}{L_i} - L_i \int_0^1 k_0^2 \in (z_i + L_i\xi)(1-\xi)^2 d\xi, & -\frac{1}{L_i} - L_i \int_0^1 k_0^2 \in (z_i + L_i\xi)\xi(1-\xi) d\xi \\ -\frac{1}{L_i} - L_i \int_0^1 k_0^2 \in (z_i + L_i\xi)\xi(1-\xi) d\xi, & \frac{1}{L_i} - L_i \int_0^1 k_0^2 \in (z_i + L_i\xi)\xi^2 d\xi \end{bmatrix} \tag{36}$$

Since the second and third terms of the left side of formula (16) are boundary elements, on the element e_1 we have

$$jk_0 E(0)\varphi(0) = \{\delta^*\}^T_{e_1} \begin{bmatrix} jk_0 & 0 \\ 0 & 0 \end{bmatrix} \{\delta\}_{e_1}$$

Therefore, in e_1

$$(K_{11})_{e_1} = \frac{1}{L_1} - L_1 \int_0^1 k_0 \in (z_1 + L_1\xi)\xi^2 d\xi + jk_0 \tag{37}$$

Similarly, in e_{N-1}

$$(K_{22})_{e_{N-1}} = \frac{1}{L_{N-1}} - L_{N-1} \int_0^1 k_0^2 \in (z_{N-1} + L_{N-1}\xi)\xi^2 d\xi + jk_0 \tag{38}$$

Therefore the right end term of formula (16) is now

$$2jk_0\varphi(0)=\{\delta^*\}_{e_1}^T\begin{bmatrix}2jk_0\\0\end{bmatrix} \tag{39}$$

Denote

$$\{F\}_{e_i}=\begin{cases}\begin{bmatrix}2jk_0\\0\end{bmatrix}, i=1\\ \begin{bmatrix}0\\0\end{bmatrix}, i\neq 1\end{cases} \tag{40}$$

Substituting formulae (35), (37), (38) and (40) into formula (16), we have

$$\sum_{i}^{N-1}\{\delta^*\}_{e_i}^T[K]_{e_i}\{\delta\}_{e_i}=\sum_{i}^{N-1}\{\delta^*\}_{e_i}^T\{F\}_{e_i}$$

which can be written as the array equation for the entire region

$$\{\delta^*\}^T[K]\{\delta\}=\{\delta^*\}^T\{F\}$$

or

$$[K]\{\delta\}=\{F\} \tag{41}$$

This is just the finite element equation introduced by this paper, in which [K] is the field strength coefficient array on the entire region [0.d] made from iterative addition of the various elements $[K]_{ei}$. It is worthy of note that [K] is a complex array and {F} is a complex vector.

V. Computational Results and Error Estimate

Based on the finite element method derived above, we carried out computations for frequencies of f = 400MHz, 4,000MHz, and 10GHz and obtained the distribution of the electric field within the plasma.

Based on formula (7) we got the reflection coefficient, R, the power reflection coefficient, r, and the power loss, L_r, caused by reflection

$$R=E(0)-1 \tag{42}$$

$$r=RR^* \tag{43}$$

$$L_r=10\log_{10}\frac{1}{1-r} \tag{44}$$

Also, based on formula (11) we got the transmissivity, T, the power transmissivity, t, and the total power loss, L, produced by the plasma sheath:

$$T=E(d) \tag{45}$$

$$t=TT^* \tag{46}$$

$$L=10\log t \tag{47}$$

From this we got the absorption loss, L_A, for within the plasma sheath

$$L_A = L - L, \tag{48}$$

These results are arranged in Table 1.

Table 1. Power losses at different frequencies

frequency (MHZ) \ power loss (db)	reflection power loss L_R	absorption power loss L_A	total power loss L
400	3.62	8.90	12.52
4000	2.55	14.69	17.24
10, 000	1.75	8.21	9.96

Based on the error estimates of the linear interpolation

$$\max_{z \in G} |E(Z) - E_F(Z)| \leq \frac{1}{8} h^2 \max |E''(E)| \tag{49}$$

in which E(z) is the true solution, $E_F(Z)$ is the finite element solution, and h is the maximum value of an element length. There is a detailed exposition of formula (49) with respect to the error analysis of linear elements in reference (9). From this we can estimate the maximum error of the field within $0 \leq Z \leq d$. Then, based on formulae (42) to (48), we can get the power loss range of the error. At frequencies of 400MHz, 4,000MHz, and 10GHz, the relative errors in the power loss were 0.1 percent, 2.9 percent, and 9 percent. From the table it is evident that for f = 10GHz, the maximum error does not exceed 1db. From formula (49) it is clear that when h is small, i.e. the network dissection is finer, the error can be made much much less. Compared with the computational results for B = 0 in reference (10), it was close for the absorption power loss in reference (10) using plane wave lamina and for the reflection power loss using a homogeneous effective thickness. We know from a comparison with the results of Table 1, that it is more precise to use the plane waves of equally divided layers to compute the absorption power loss and that using a homogeneous effective thickness for this purpose gives results on the high side.

Consequently, this paper has provided a simple yet precise method for computing an actual plasma sheath with respect to signal attenuation. This sort of method can be used for transmission problems of electromagnetic waves in laminar medium of any cross sectional variation.

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12966/7358

THEORETICAL AND EXPERIMENTAL STUDY OF Nd:YAG SLAB LASER

40090001 Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 7 No 7, Jul 87 pp 577-583

[English abstract of article by Liu Yagang [0491 0068 6921], et al., of Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences]

[Text] This paper presents a theoretical and experimental study of a slab laser. Analytical solutions of temperature and stress distributions for CW and pulse pumping conditions are given. The authors analyze and discuss the thermal distortion in the slab. The measurement and analysis of the thermal effect using a 9 x 30 x 70 mm^3 Nd:YAG slab have been carried out. A high repetition rate zig-zag slab laser has been put into operation, with an output energy per pulse at 50 Hz of approximately 600 mJ and average power of 30 watts. (Received 4 Sep 86; revised 18 Nov 86.)

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FIR TUNABLE RAMAN LASER THEORY

40090001 Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 7 No 7, Jul 87 pp 584-590

[English abstract of article by Wang Changxin [3769 7022 6580], et al., of Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences]

[Text] In this paper, the authors use the dressed-atom approach to derive the analytical expression for the gain of a FIR laser with a four-level system. The results indicate that the FIR laser gain spectrum generally consists of four peaks. For some pump detuning ranges it is possible to obtain two positive gain maxima--one at the Raman frequency and the other at the line center frequency. (Received 28 Nov 86.)

9717

EFFECTS OF GROUND STATE DEPLETION OF ATOMS IN STIMULATED RAMAN SCATTERING OF METAL VAPORS

40090001 Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 7 No 7, Jul 87 pp 591-596

[English abstract of article by Huo Yunsheng [7202 5366 3932], et al., of Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences]

[Text] The effects of ground state depletion of atoms on the characteristics of stimulated Raman scattering in metal vapors are studied by simultaneously solving the rate equation of the related atomic energy levels in the Raman scattering and the equations describing the energy-conversion from the focused pump laser pulses to the Raman down-converted pulses. The ground state of the metal ions is depleted most strongly in the regions near the focal spots of the pump beams due to the higher intensities of light and smaller available medium volume in those regions. This will result in asymmetrical shapes of the Raman-shifted pulses for the front and rear edges, and will reduce the energy-conversion efficiency. (Received 4 Sep 86.)

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RESONANCE FLUORESCENCE SPECTRUM OF ATOMS ABSORBED ON METAL OR DIELECTRIC SURFACE

40090001 Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 7 No 7, Jul 87 pp 597-601

[English abstract of article by Liu Zhengdong [0491 2973 2639] of the Department of Physics, Jiangxi Teacher's University, Nanchang; Li Xiaoshen [2621 1321 3947] of the Department of Physics, Nanjing University]

[Text] By means of the linear response method, the surface-dressed optical Bloch equations (SBE) for atoms absorbed on a solid surface are obtained. These SBE are different from the earlier ones. The difference lies in the fact that here the influences of the solid surface on the spontaneous decay rate and the Lamb shift of the adsorbed atoms have been taken into account. Using the SBE and the regression theorem, the resonance fluorescence spectrum for the adatoms are obtained. Through analyzing these spectra numerically, it is found that the solid surface will exert a significant influence both on the sidebands and on peak heights. When the adatoms approach the surface, the distance between the two sidebands will become larger and the height for each peak will go down until the peaks disappear, one by one. (Received 25 Sep 86; revised 3 Nov 86.)

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OPTICAL PROPERTIES OF VERY THIN METAL Ag FILMS

40090001 Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 7 No 7, Jul 87 pp 629-636

[English abstract of article by Zhang Xu [1728 2485], et al., of the Department of Radioelectronics, Beijing University]

[Text] Dependencies of the equivalent Lorentz vibration and interband transition on the thickness and steady-state time relevant to the free and bound electrons in Ag thin films are discussed. Based on spectral transmittances of Ag films with different thicknesses and different steady states in the visible region, the findings are made in combination with the effective medium theories of island films of metals.

Theoretical calculations of the spectral transmittance agree very well with the experimental results. By comparing the theories with the experiments, the optical constants of Ag films with different thicknesses and different steady states are obtained. (Received 25 Sep 86; revised 15 Dec 86.)

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NEW KIND OF HETERODYNE FIBER-OPTIC GYROSCOPE

40090001 Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 7 No 7, Jul 87 pp 662-666

[English abstract of article by Peng Gangding [1756 4854 1353], et al., of the Department of Electronic Engineering, Shanghai Jiaotong University]

[Text] In this paper, a new fiber-optic heterodyne detection technique for rotation rate is described. Using an electro-optic frequency shifter and highly birefringent single-mode fiber, the heterodyne fiber-optic gyroscope system no longer requires the use of acousto-optic devices and is free from the direct-current drift in electronics. In addition, the reciprocity of the optical path in the system is improved. Preliminary results have shown a good linearity of the scale factor. (Received 9 Oct 86.)

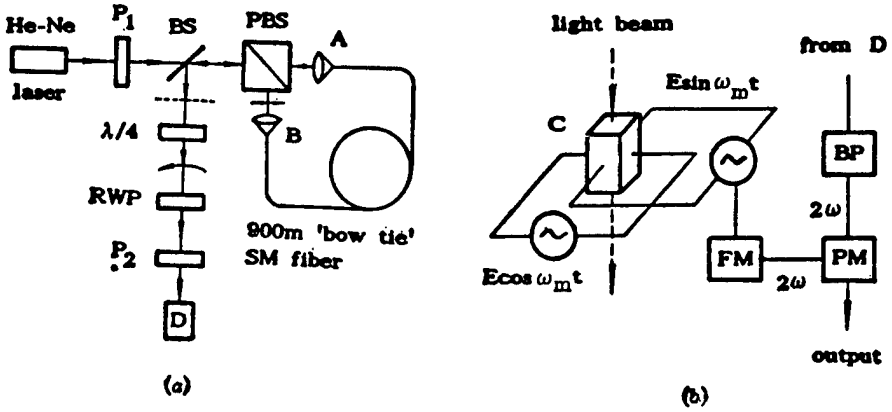

Fig. 1 Schematic diagrams of the gyroscope configuration

(*a*) Using a rotating wave plate as its frequency shifter. BS, beam splitter; PBS, polarization selective beam splitter; P_1, polarizer; P_2, analyzer; D, detector;

(*b*) Using a $LiNbO_3$ crystal *C* as its frequency shifter instead of the RWP in Fig. 1(*a*). FM, frequency multiplier; BP, bandpass filter; PM, phasemeter

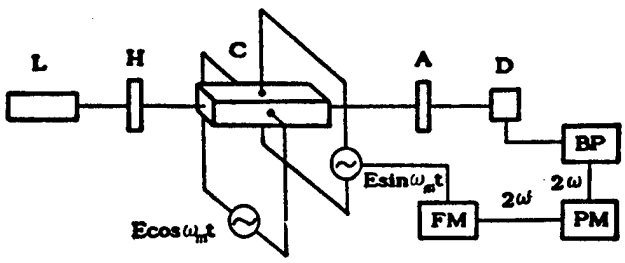

Fig. 2 Experimental set-up of the $LiNbO_3$ electro-optic frequency shifter. L, He-Ne laser; H, halfwave plate; C, $LiNbO_3$ crystal; A, analyzer; *D*. detector; BP, bandpass filter; FM, frequency multiplier; PM, phasemeter

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NETWORK-BOUNDARY ELEMENT METHOD FOR ANALYSIS OF EM CIRCUITS

40090005 Beijing TONGXIN XUEBAO [JOURNAL OF CHINA INSTITUTE OF COMMUNICATIONS] in Chinese Vol 8 No 3, May 87 pp 21-31

[English abstract of article by Feng Zhenghe [7458 2973 0735] of Qinghua University]

[Text] This paper describes a new method combining the network method with the boundary element method (BEM) for analyzing EM circuits. This method can directly calculate the network parameters of planar circuits. An arbitrary multi-port planar circuit can be divided into several subregions according to the boundary or medium conditions. In each subregion, an integral equation can be obtained with its own fundamental solution. In the port's subregion, the fundamental solution of the transmission line constitutes the integral equation. The fields on both end boundaries can be expanded by intrinsic and boundary elements, respectively. Therefore, the network parameter can be dealt with as a boundary condition.

This method requires fewer nodes and is flexible and convenient for many problems. A program is designed to solve multi-mode, multi-port and multi-medium circuit and radiation problems.

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SHAPE ANALYTICAL METHOD FOR TWO-DIMENSIONAL OBJECTS

40090005 Beijing TONGXIN XUEBAO [JOURNAL OF CHINA INSTITUTE OF COMMUNICATIONS] in Chinese Vol 8 No 3, May 87 pp 61-67

[English abstract of article by Lu Xinru [7120 1800 1172], et al., of Northwest Telecommunication Engineering Institute]

[Text] A method of shape analysis based on the R transformation is presented in this paper. The method is appropriate for shape analysis of two-dimensional images of objects. By analyzing some typical contours of two-dimensional images with the Fourier and R descriptors described in this paper, the results obtained show that both descriptors are of good and recognizable performance. However, the R descriptor is superior to the Fourier descriptor in both computational speed and storage requirements. The R descriptor can be applied to the classification of aircraft types and three-dimensional motion analysis and tracking of aircraft. The experimental results indicate that the method presented provides a good performance.

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BLURRED IMAGE SEGMENTATION USING FUZZY THEORY

40090005 Beijing TONGXIN XUEBAO [JOURNAL OF CHINA INSTITUTE OF COMMUNICATIONS] in Chinese Vol 8 No 3, May 87 pp 68-75

[English abstract of article by Xu Yuanpei [1776 0337 1014], et al., of the Space Science and Technology Center, Chinese Academy of Sciences]

[Text] This paper presents an approach for segmenting blurred images using fuzzy concepts. The edge membership function of a blurred object is first established. Then, three kinds of segmentation are discussed, including the λ truncation set, countour tracking and region growing. A 32 x 32 image of a cell is used for computer simulation, and the results obtained are satisfactory.

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PASCAL INTO C TRANSLATING TOOL: PTOC SOFTWARE

40090002 Beijing JISUANJI YANJIU YU FAZHAN [COMPUTER RESEARCH AND DEVELOPMENT] in Chinese Vol 24 No 3, Mar 87 pp 8-13

[English abstract of article by Zhou Changle [0719 2490 2867] of the Department of Computer Science, Dalian Institute of Technology]

[Text] Using theories presented in the references, the authors have implemented a multifunction system for language translation--the PTOC software. In addition to translating PASCAL into C, the software also includes several other functions. This software can be regarded as a practical tool not only for translating languages and replacing PASCAL in computers with C, but also in providing an automatic transplanting tool between PASCAL and C.

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EASYCODE--APPLICATION DEVELOPMENT ENVIRONMENT MAKING MICROCOMPUTERS MORE INTELLIGENT

40090002 Beijing JISUANJI YANJIU YU FAZHAN [COMPUTER RESEARCH AND DEVELOPMENT] in Chinese Vol 24 No 3, Mar 87 pp 51-57

[English abstract of article by Sheng Haolin [4141 3185 2651], et al., of the Computer Department, East China University of Chemical Technology; Gu Yuqing [7357 3022 3237] of the Institute of Software, Chinese Academy of Sciences]

[Text] EASYCODE is an integrated and intelligent application development environment implemented on microcomputers. The application development cycle comprises only three phases, i.e., application definition, generation and execution. As a consequence, improvement by orders of magnitude in software productivity can be achieved.

This paper presents a brief overview of the EASYCODE environment and its functions, discusses how to attain the tool integration through concept integration and how to make EASYCODE more intelligent, emphasizing the important role of activity and form dictionaries.

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IMPLEMENTATION OF CHINESE-ENGLISH COMPATIBLE SCREEN EDITOR

40090002 Beijing JISUANJI YANJIU YU FAZHAN [COMPUTER RESEARCH AND DEVELOPMENT] in Chinese Vol 24 No 3, Mar 87 pp 58-65

[English abstract of article by Chen Yiqing [7115 0001 3237] of the Institute of Software, Chinese Academy of Sciences]

[Text] The vi screen editor is one of the most useful utilities in the UNIX system. This paper outlines the environment for running the vi program and the goals and significance of the Chinese-characterized vi. A discussion is then presented of the 10 major problems encountered during characterizing the vi program with Chinese. Finally, a description is given of the methods for implementing the Chinese-English compatible screen editor.

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DEVELOPING STRATEGY FOR FIRMWARE ENGINEERING

40090003 Beijing JISUANJI YANJIU YU FAZHAN [COMPUTER RESEARCH AND DEVELOPMENT] in Chinese Vol 24 No 7, Jul 87 pp 1-6, 13

[English abstract of article by Chen Bingcong [7115 3521 1783], et al., of North China Institute of Computing Technology; Yao Xin [1202 2450] of the University of Science and Technology of China]

[Text] This paper briefly presents some microprogramming experiences, noting that one of the primary backgrounds for developing firmware engineering is the function migration of system software. In addition, this paper goes further into the current major research fields and directions of firmware engineering. It also explores the present status of microprogramming and firmware engineering as well as practices in these fields in China.

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ON RECOGNITION OF HANDPRINTED CHINESE CHARACTERS

40090003 Beijing JISUANJI YANJIU YU FAZHAN [COMPUTER RESEARCH AND DEVELOPMENT] in Chinese Vol 24 No 7, Jul 87 pp 14-22

[English abstract of article by Wang Linquan [3769 2651 3123] of Shanghai University of Science and Technology]

[Text] Research involving handprinted Chinese characters is becoming very active, particularly in China and Japan. In this paper, articles on the recognition of handprinted Chinese characters, which have been reported chiefly in Trans. IECE Japan and Trans. IPS Japan, are analyzed and synthesized with the KJ method. The present situation and developments in the field of recognizing handprinted characters are described. Typical methods and technology of recognition of handprinted characters are introduced, and some future directions are discussed.

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TECHNIQUES OF IMAGE MEMORY DESIGN

40090003 Beijing JISUANJI YANJIU YU FAZHAN [COMPUTER RESEARCH AND DEVELOPMENT] in Chinese Vol 24 No 7, Jul 87 pp 23-31, 44

[English abstract of article by Zhu Chuannai [2612 0278 0035] of the Institute of Computing Technology, Chinese Academy of Sciences]

[Text] This paper describes important roles of image memory in high resolution display (a 1024 x 1024-pixel display) and discusses features of a dynamic RAM chip. In addition, the influence of the memory chips on the allocation of memory cycles across the scan line to the video refresh controller and display processor is also discussed, and different ways for the image memory design to meet the needs of high resolution display are presented.

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PRELIMINARY STUDY OF FRONTS IN WESTERN PART OF SOUTHERN YELLOW SEA

40082027 Beijing HAIYANG YU HUZHAO [OCEANOLOGIA ET LIMNOLOGIA SINICA] in Chinese Vol 18 No 3, May 87 pp 217-226

[Article by Zhao Baoren [6392 0202 0088] of the Chinese Academy of Sciences Institute of Oceanology at Qingdao: "A Preliminary Study of Continental Shelf Fronts in the Western Part of the Southern Yellow Sea and Circulation Structures in the Front Region of the Yellow Cold Water Mass (HCWM)*"]

[Text] Abstract: This article is based on actual measurements of hydrological data and satellite images to point out the existence of a shallow-water continental shelf front formed by tidal mixing in the western part of the southern Yellow Sea. It analyzes hydrological structures in the continental shelf front region and points out the existence of a low-temperature, high-salinity and high-oxygen zone in the frontal region of the cold water mass in the upper layer of the sea that is formed by the rising of lower cold water layers. The area of primary rising currents in the Yellow Sea is along the boundary between the continental shelf front and the cold water mass. The article also points out that alongshore currents in the Yellow Sea during the summer mainly involve a jet flowing southward along the Yellow Sea cold water mass front. During periods of decline in the cold water mass, shrinkage of the cold water mass is accompanied by the seaward migration of this current along the front.

The shallow-water continental shelf front is the boundary between the coastal region of complete mixing and the outer-sea stratified region. The position of the continental shelf front is related to the Simpson-Hunter parameter which indicates the degree of intensity of tidal mixing[11]. In essence, this parameter concerns the combined effects of tidal current flow rates and water depth (and topography). Generally speaking, a shallow-water continental shelf front appears in the shallow-water and weak-current areas of the sea where there is substantial depletion of tidal energy and rather obvious seasonal variations in water and air temperature[8,9,11].

The Yellow Sea is an oceanic region with excellent conditions for the production of shallow-water continental shelf fronts. The reasons are:

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*Survey Research Report No. 1296 of the Chinese Academy of Sciences Institute of Oceanology

(1) There is considerable tidal energy in the Yellow Sea. According to calculations by Fang Guohong [2455 0948 3163], tidal energy in the Yellow Sea may reach 2.3 x 10^{15}J, which is about 80 percent of the total marine energy in the Yellow Sea[1]. Most of the tidal energy which enters the Yellow Sea is dissipated locally, however; (2) There are extremely obvious changes in water temperature in the Yellow Sea, with an annual variation in water temperature for most of the water in the area that reaches or exceeds 20°C; (3) Marine currents in the Yellow Sea are rather weak, generally only 10 cm/second. The author[4] has used the Simpson-Hunter parameter to discuss stratification in the Yellow Sea during the summer and the question of the continental shelf front. This article will attempt to use far-infrared satellite photographs and hydrological data obtained from a joint Sino-American survey (July 1984) for a further confirmation of the existence of a shallow-water continental shelf front caused by tidal mixing. Another goal of this article is to describe the phenomenon of rising currents related to the boundary of the cold water mass in the Yellow Sea and the related hydrological characteristics. Others have been concerned with analyzing and studying the question of rising currents in the central part of the Yellow Sea cold water mass for some time[7,8], but it was quite difficult to employ this concept to explain certain hydrological phenomena in the Yellow Sea. For example, although the central area of the cold water mass is the primary region of rising currents, why is it that in cross-section the isothermal contours in the central part of the cold water mass do not swell upward but instead sag downward during most months (particularly during the summer and fall)? Why is it that an extremely obvious high-oxygen layer always can be found at the bottom of the autumn thermocline, which lies near the upper boundary of the cold water mass[2,4]? This article is based on actual data and points out the existence of another important area of rising currents in the Yellow Sea, the frontal rising current region, and thereby offers a more satisfactory explanation of the hydrological phenomena mentioned above.

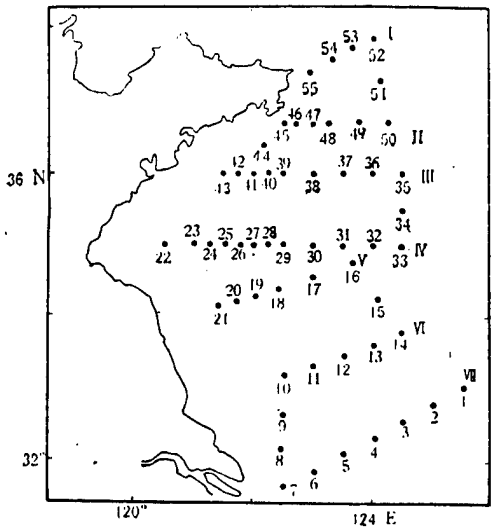
I. The Continental Shelf Front in the Western Part of the Southern Yellow Sea

1. A typical continental shelf front section

Although no special surveys were carried out concerning the question of continental shelf fronts in the Yellow Sea during the July 1984 survey (see Figure 1 for station locations), the data obtained indicate that a continental shelf front cuts precisely through the northern side of the shallow beaches in northern Jiangsu in section V. The sectional distributions of temperature, salinity, dissolved oxygen and other factors of this section are shown in Figure 2. It is apparent from Figure 2a that station 19 is the boundary of the temperature section. There are obvious differences in the distributional trends of the isotherms on the eastern and western sides. The western side is a region of complete mixing and the water temperature is in a vertically homogenous state, while the eastern side is a stratified region. The lowest surface (2-meter layer) temperature is found at station 19, which is 3 to 5°C lower than the temperature at the two sides. It also is apparent from Figure 2a that a rather large area of horizontal water temperature gradients exists on the surface at the eastern and western sides of this low-temperature region. The temperature gradient (0.13°C/kilometer) of the eastern side is

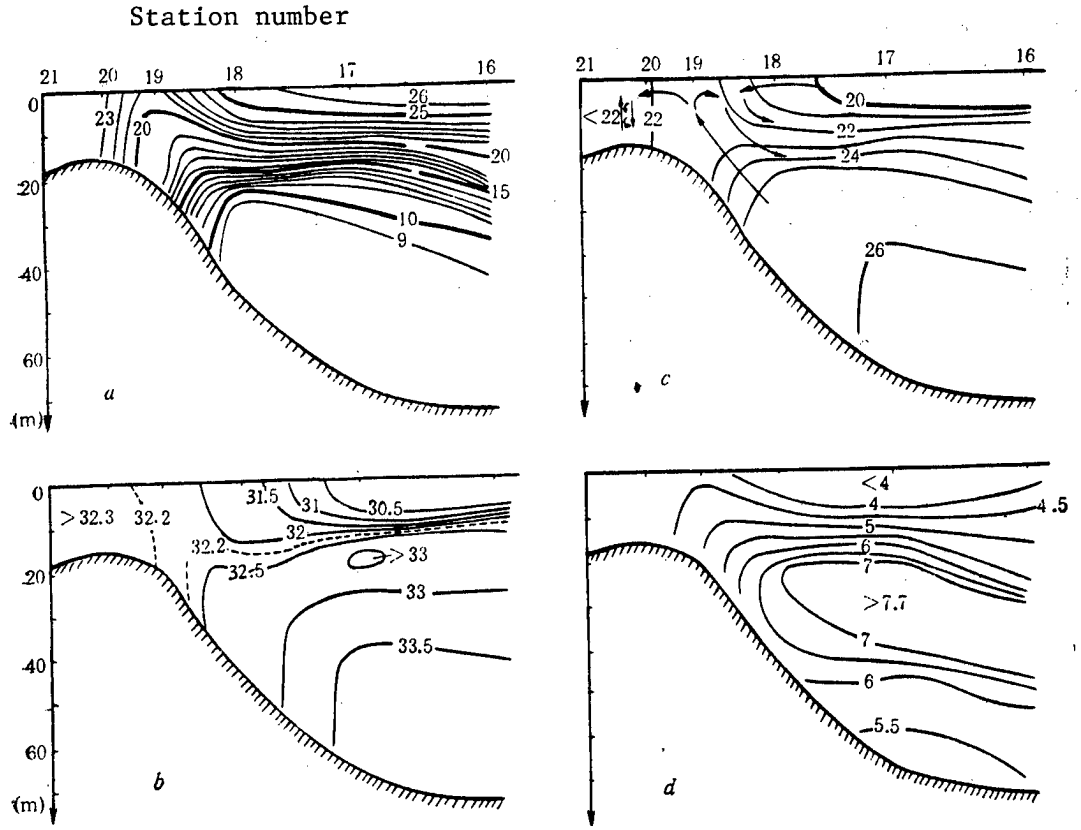
obviously greater than that of the western side. This is the shallow-water continental shelf front mentioned previously. Trends in the temperature distribution in the stratified region indicate that the isotherms in the upper half of the thermocline near station 19 bend upward and intersect the surface, while the isotherms in the lower half curve downward and intersect the sea bottom. The distributional trends in the entire section are extremely close to an ideal temperature distribution pattern for a continental shelf front region[3,9]. The satellite images shown below indicate that the actual horizontal temperature gradient must be much greater at the surface in the front region.

Figure 1. Location of Stations in July 1984 Survey



The arrow in Figure 2a shows the position of the critical stratification parameter value 1.8 that was calculated by the author using the near-maximum tidal current flow rate[3]. The arrow is located precisely in the upper part of the front region and thereby illustrates the role that tidal mixing plays in controlling the position of the continental shelf front. It also is apparent from the temperature distribution shown in section V that the isotherms near the low-temperature region at the surface show an obvious rise, which points out the phenomenon of an obvious upwelling in the bottom layer cold water mass near the Yellow Sea continental shelf front.

Figure 2. A Typical Continental Shelf Front Profile (Section V)



Key:

a. Temperature
b. Salinity
c. Density
d. Dissolved oxygen

(Author's note: The "↓" is missing between stations 19 and 18 in Figure 2a)

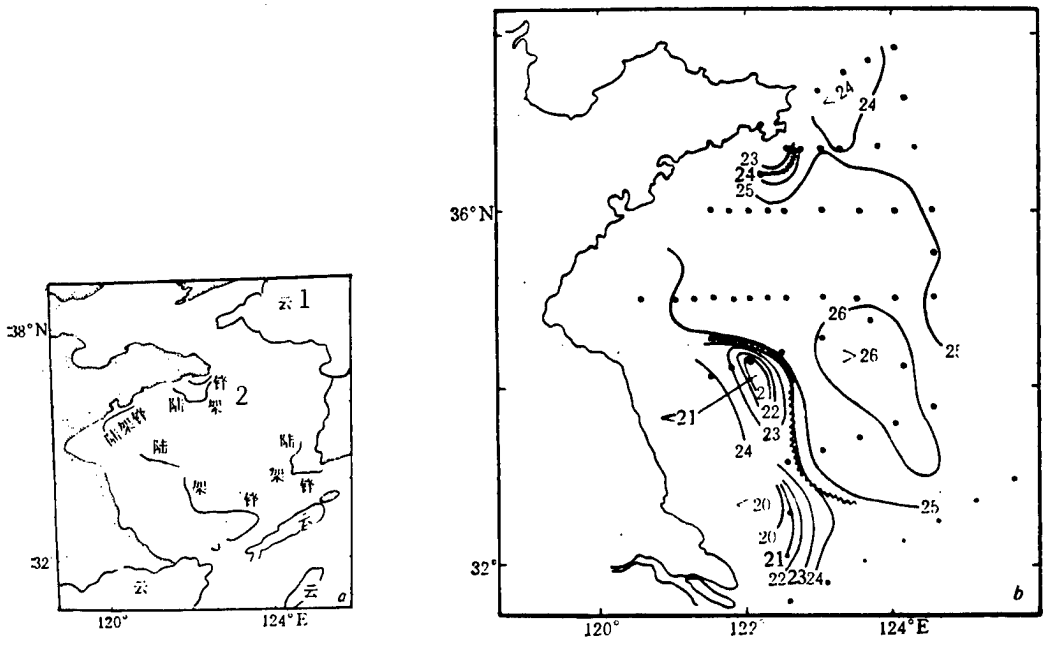
The sectional distribution of salinity and density (Figures 2b and 2c) are almost completely identical to the temperature section in that station 19 also serves as their boundary, with the western side being a vertically homogenous region and the eastern side being a stratified region. It is especially important to point out here that: (1) The salinity in the vertically homogenous area on the western side of the cross section obviously is greater than the salinity of the upper layer in the stratified region on the eastern side; (2) There is a rather thick area of low salinity in the upper layer at station 18, while there are high salinity values near the 18-meter layer at station 17. This is an obvious indication of a mixing process like the one described below in that the rising highly-saline water near the front region subsides in the continental shelf front region after mixing with the low-salinity water in the upper layer on the eastern side of the section, after which it disperses eastward at the upper boundary of the cold water mass along

the equal-density contours (as shown by the arrows in Figure 2c). In the chart showing the cross-sectional distribution of dissolved oxygen (Figure 2d), there is an obvious upward tilt in the high-oxygen layer near the bottom of the thermocline and the high-oxygen layer rises ever-higher as one moves closer to the front region. Obviously, all of the distributional characteristics of temperature, salinity, density and dissolved oxygen are related organically to the special circulational structure of the continental shelf front.

2. The horizontal distribution of the continental shelf front

Plate I is a far-infrared satellite (NOAA-7) photograph of the southern Yellow Sea taken at 1839 GMT on 15 July 1984. Plate I shows clearly that there is an milky white low-temperature region seaward from northern Jiangsu. There is a clear boundary between the low-temperature region and the far-sea high-temperature region, which is the surface continental shelf front that we have discussed. In addition, there also is a low-temperature region covering a small area but with a clear boundary offshore from Qingdao and Shidao Island at the eastern tip of the Shandong peninsula. The position of the fronts associated with these low-temperature regions are identical to the distributional tendencies of the critical value of the Simpson-Hunter stratification parameter provided in reference [3]. To see this clearly, the illustration of Plate I provided in Figure 3a indicates the locations of the coastline and the fronts. Figure 3b shows the temperature distribution situation for the 2-meter layer at the same time. The figure shows that the surface temperature distribution reflected in the satellite photograph conforms completely with the results of actual measurements made by ships at sea.

Figure 3. Distribution of the Surface Continental Shelf Front



a. Diagram explaining Plate I b. Temperature distribution in the 2-meter layer

Key: 1. Cloud 2. Continental shelf front

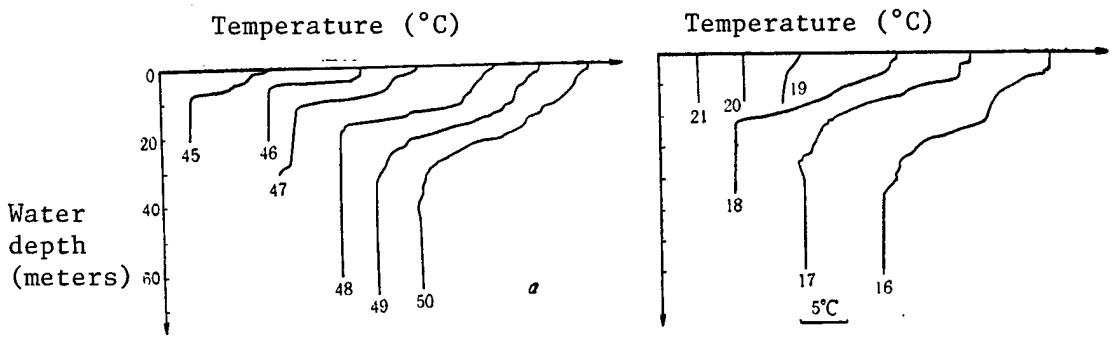
II. The Phenomenon of Rising Currents at the Boundary Region of the Yellow Sea Cold Water Mass (the Front Region)

In previous research, people were concerned with the question of rising currents in the central region of the Yellow Sea cold water mass[6,7]. Certain characteristics of their hydrological distribution, however, led them to think that a region of other rising currents that are even more commonplace might be found in the Yellow Sea. Xia Congwan [1115 4844 8001] and Guo Binghuo [6753 3521 3499][5,10], for example, have used the obvious surface low-temperature region offshore from Chengshanjiao and Luda as a basis for pointing out the existence of rising currents caused by tidal currents. Analysis in the previous section indicates not only that there are rising currents in the two above-mentioned sea regions and that there possibly may be upward movement of the seawater at the boundary of the entire Yellow Sea cold water mass, but the phenomenon of rising currents may be found more obviously in the clear area of the continental shelf fronts. Because of the limited scope of the survey, only the rising currents at the boundary of the cold water mass in the western part of the Yellow Sea can be discussed here.

1. The up-mixing layer

We first of all derived the vertical temperature changes for each station in sections II and V as representative values to discuss latitudinal changes in the thickness of the up-mixing layer (Figures 4a and 4b). One can see from Figure 4 that regardless of the section, the thickness of the up-mixing layer becomes increasingly smaller moving from the outer sea toward the coast, that most of it is at the boundary of the cold water mass, and that the up-mixing layer reaches its minimum thickness at stations 18 and 46. At the same time, the thermoclines thin moving from east to west, the thermoclines grow stronger and the upper position of the lower homogenous layer moves closer to the surface until all of them reach their maximum values at stations 18 and 46. A rational explanation for the formation of such vertical temperature changes is that rather strong rising currents exist at the boundary of the cold water mass.

Figure 4. Vertical Distribution of Temperature at Each Station



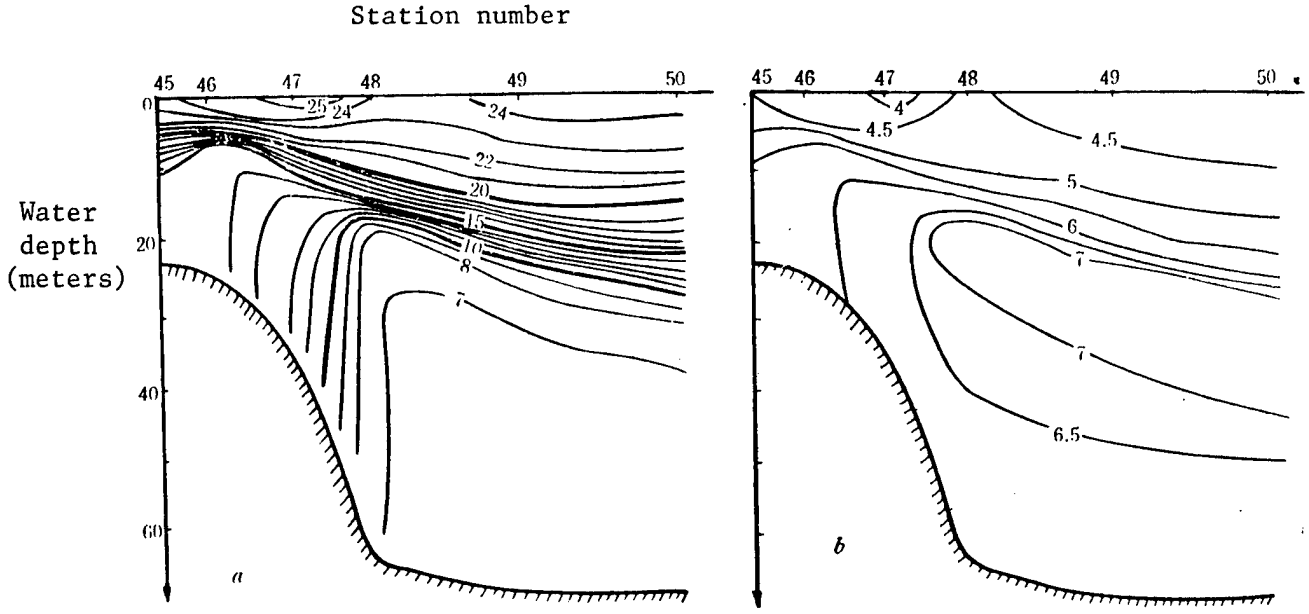
a. Section II

b. Section V

2. Sectional rising in hydrological factors

As shown in Figure 2, deep cold water may rise to the surface at section V in the Yellow Sea. A chart of the distributions of temperature and dissolved oxygen for a hydrological section near Shidao Island (section II) also shows the same type of upward movement of the seawater (Figure 5).

Figure 5. Distribution of Temperature (a) and Dissolved Oxygen (b) for Section II



As shown in Figure 5a: (1) The water temperature of the offshore surface layer is about 2.5°C lower than the far-sea surface layer water temperature while the bottom layer water temperature is higher than the far-sea bottom layer water temperature; (2) There is an obvious rise in the alignment of the isotherms and thermoclines as one moves toward the coast. The thermoclines reach their maximum rise and greatest strength at station 46 near the coast, where the upper boundary of the thermoclines almost reaches the surface, the lower boundary rises to a depth of 6 meters and the average thermoclinal strength between 4 and 6 meters reaches 4.5°C/meter.

There is an obvious tilt in the high-oxygen layer near the lower boundary of the thermoclines (Figure 5b). At station 47, which is fairly close to the coast, the center of the high-oxygen region is at a depth of 16 meters. However, at station 50, which is located at the extreme eastern side of the section, the high-oxygen layer is near 32 meters, so there is a difference as great as 16 meters between them. There is no high-oxygen layer in offshore areas.

The salinity and density distributions of the section are identical to the temperature distribution, so they will not be repeated here.

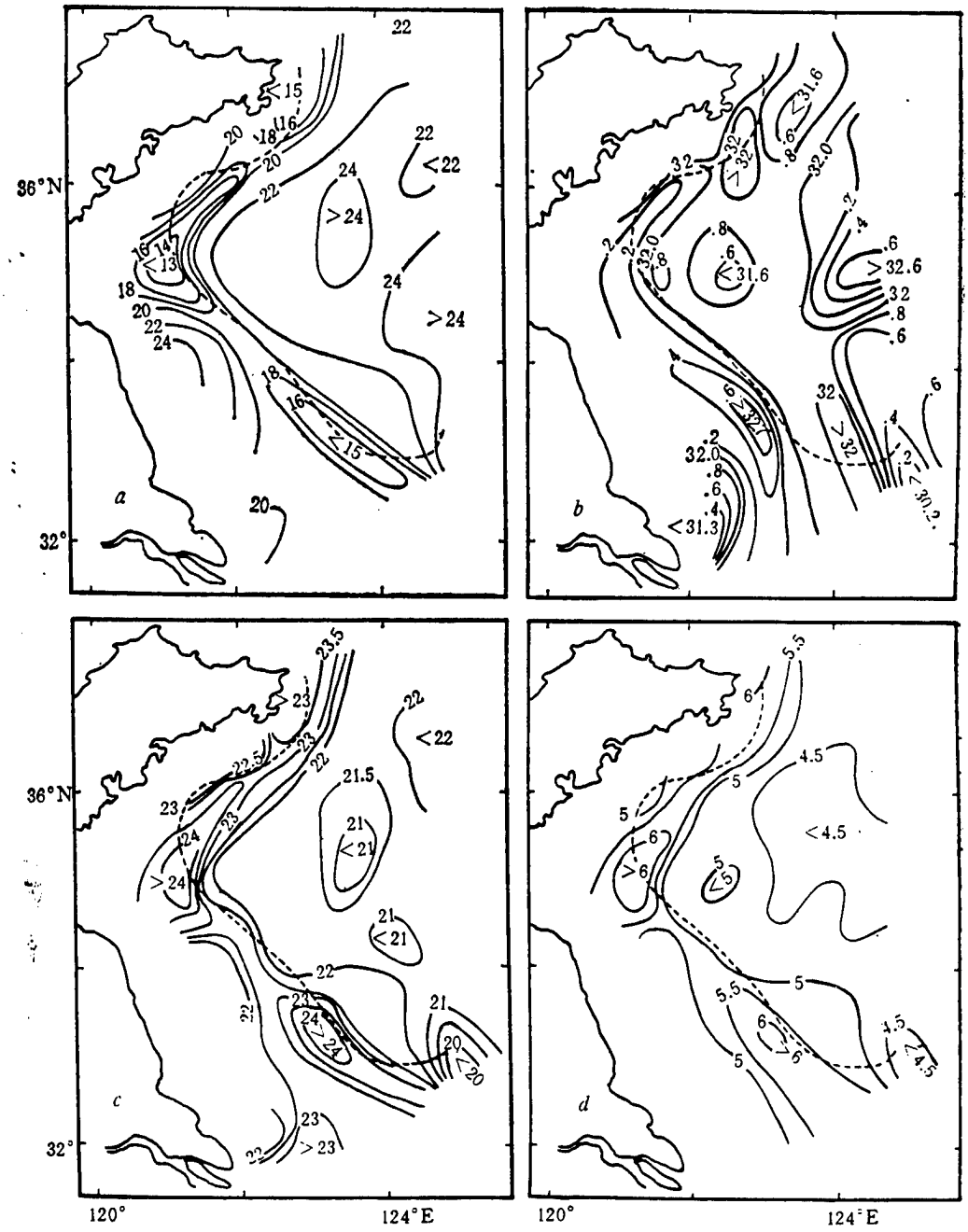
3. Characteristics of the horizontal distribution of hydrological factors in the upper layers of the front region

To describe the phenomenon of rising deep-layer cold water that is common throughout the cold water mass front region, we analyzed the horizontal distribution characteristics of hydrological factors for the 10-meter layer (Figure 6). To facilitate the analysis, Figure 6 uses the 10°C isotherm (the dotted line) to illustrate the scope of the bottom-layer cold water mass. We can see in Figure 6a that an obvious characteristic of the 10-meter layer temperature distribution is that the far-sea water temperature is higher everywhere, while there is a curved low-temperature zone in offshore regions. This low-temperature zone is distributed exactly near the boundary of the bottom-layer cold watermass, which is on the coastal side of the 10°C isotherm of the bottom layer. The observed minimum temperature in the low-temperature zone was 12.95°C, which is extremely close to the representative temperature of the Yellow Sea cold water mass. The maximum temperature of the far-sea high-temperature region was 24.88°C, so there was a difference of about 12°C between the two. In most situations, the water temperature of the low-temperature zone is about 5° to 10°C higher than the temperature at the two sides. It also can be seen in Figure 6a that there are three cold centers in the offshore low-temperature zone and that their sequential positions are the outer edge of the Lusi shoal, the mouth of Haizhouwan Bay and out to sea from Chengshanjiao and Shidao Island. The low-temperature zone distributed along the cold water front in the 10-meter layer clearly reflects the actual rising of deep-layer cold water near the front.

The shape of the salinity distribution in the 10-meter layer is slightly more complex (Figure 6b), but the overall trend is one in which it is extremely close to the temperature distribution in that there is a high-salinity zone along the Yellow Sea cold water mass front region while to the eastern side of this high-salinity zone there is a large low-salinity region in the far-sea area. The maximum salinity in the high-salinity zone is 32.79 percent, which is extremely close to the representative salinity value for the Yellow Sea cold water mass. The area of the above-mentioned low-temperature, high-salinity zone is a high-density zone (Figure 6c). Its maximum σ_t value is 24.42 and the σ_t value generally is 2 to 4 or more higher than the low density far-sea area.

The horizontal distribution tendencies for dissolved oxygen in the 10-meter layer (Figure 6d) is basically the same as the distributional trends for temperature, salinity and density. This means that a high-oxygen zone exists near the cold water mass front and that there are three high-oxygen centers (with dissolved oxygen in excess of 6 ml/liter) in the high-oxygen zones which correspond exactly with the low-temperature centers in the low-temperature zone shown in Figure 6a. The appearance of a high-oxygen zone in the 10-meter layer provides an additional indication that cold water in the deep bottom layer of the Yellow Sea has risen to the 10-meter layer and above near the boundary of the cold water mass. Actually, the distribution of hydrological factors in the 2-meter layer indicate (in illustration) that the rising movement described above may extend to near the surface in many areas.

Figure 6. Horizontal Distribution of Temperature (a), Salinity (b), Density (c) and Dissolved Oxygen (d) for the 10-Meter Layer



The phenomenon of rising of the deep-layer cold water near the cold water mass front illustrates the complexity of the radial circulation structure of the Yellow Sea cold water mass. Further clarification of the radial circulation structure of the entire Yellow Sea cold water mass is of great theoretical and practical significance.

III. Yellow Sea Shore Currents That Flow Along the Cold Water Mass Front

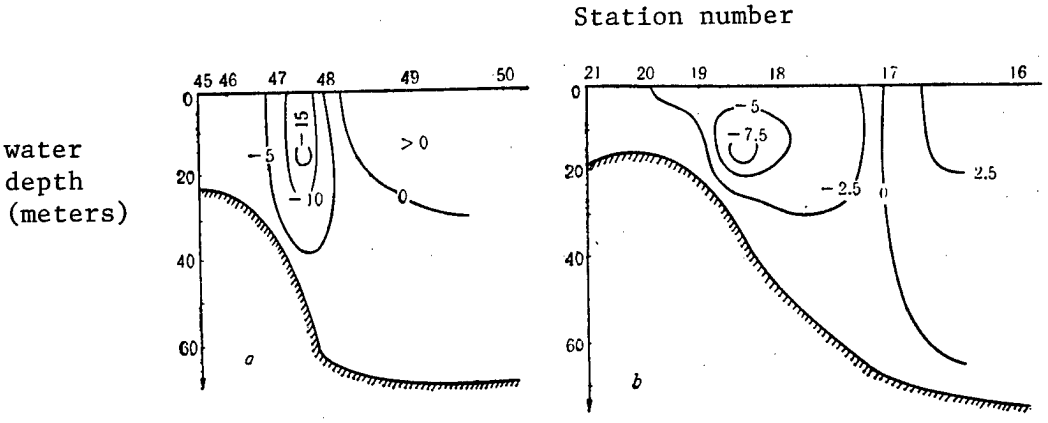
In the western part of the southern Yellow Sea, there is perennial continental alongshore water along one side of the Chinese mainland, which is the so-called southward-flowing Yellow Sea alongshore current. This concept is almost identical to the views of Chinese and foreign scholars. Very few, however, have discussed the nature and dynamic mechanisms of the Yellow Sea alongshore currents. The author feels that the summer Yellow Sea alongshore current is primarily a front region jet that flows southward along the cold water mass front. Here, we will rely mainly on the distribution of mass fields and the related hydrological factors to illustrate this concept.

1. Geostrophic currents

This article employed a survey of the depth of the bottom layer at the deepest far-sea measurement stations as the dynamic zero plane after which a shallow-water correction was made for the dynamic elevation of each station in sequence.

In Figure 7 we can see that the geostrophic currents to the west of the center of the section flow southward while the geostrophic currents in the eastern part of the section flow to the north. Near the boundary of the cold water mass in the western part (see Figure 2), there is a high flow rate area that flows southward. The maximum vertical flow rates calculated for these two sections are 15 cm/second and 7.5 cm/second, respectively. The maximum flow rate value is found not at the surface but instead in a secondary surface layer about 15 meters deep. Because of the rather substantial distance between the measurement stations, the thickness of the front that actually exists must be much narrower, so it is possible as a result that the actual geostrophic flow rates may be much larger than the numbers mentioned above.

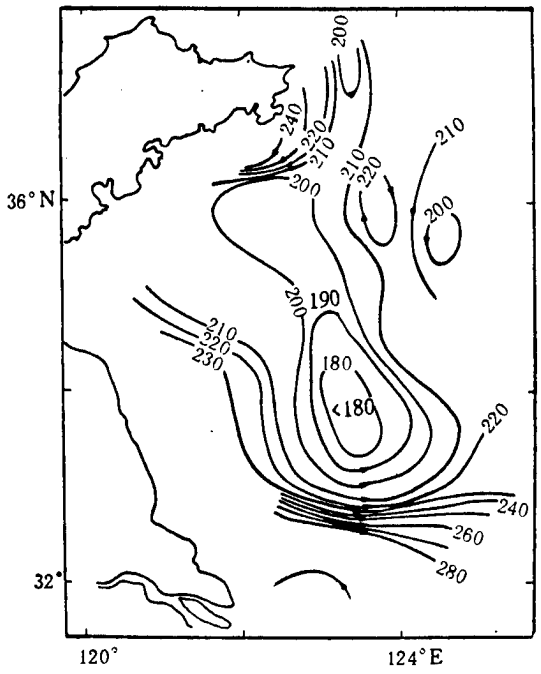
Figure 7. Geostrophic Current Flow Rate Section
(Units: cm/second)



a. Section II b. Section V

The horizontal distributions of the geostrophic currents (Figure 8) show that there is counter-clockwise cold water mass circulation in the surveyed area of the sea, with the marine currents on the west side flowing southward and those on the east side flowing roughly northward. Moreover, there is rather good correspondence between the measured afterflow and the geostrophic currents. This shows that the dynamic elevation contours in the chart may in large part represent the actual current field during the observation period. Like Figure 7, the area of the sea in the chart where the geostrophic flow rates are higher is found near the boundary of the cold water mass.

Figure 8. Dynamic Elevations of the 10-Meter Layer
(Units: dyn.mm)



We can know from this that in regard to the geostrophic current field, the high flow rate region in the western part of the Yellow Sea appears in the cold water mass front region.

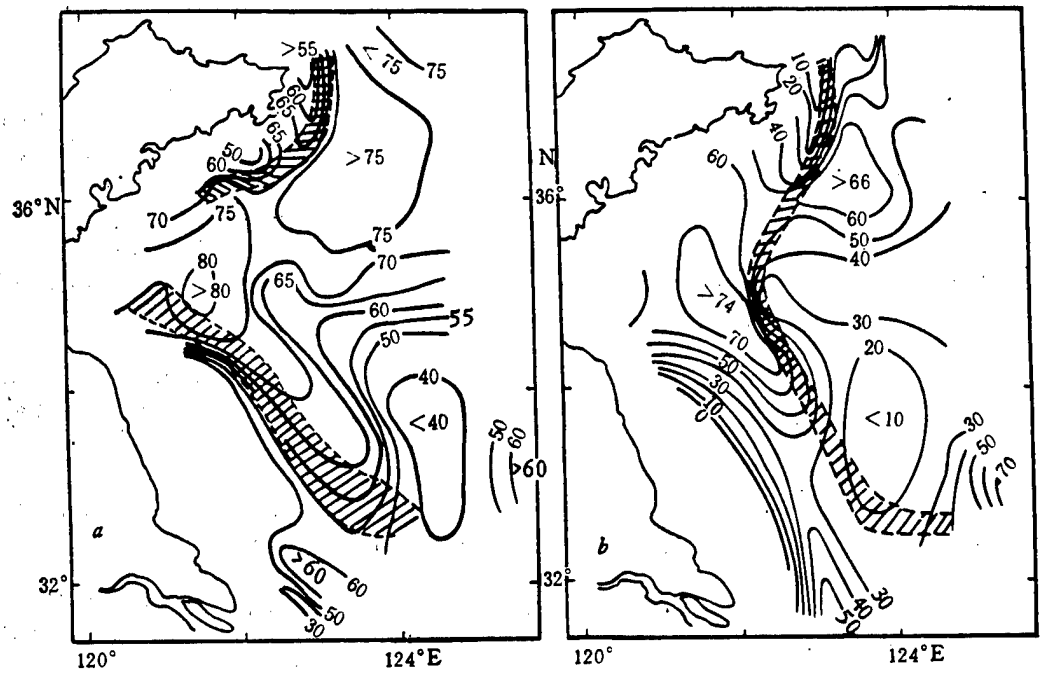
2. The distribution of transmittance and alongshore currents in the Yellow Sea

We have discussed previously the distribution of transmittance in the southern Yellow Sea at the end of autumn and its relationship to circulation and water masses[4]. The results obtained were satisfying. Here, we will examine only the distribution of transmittance to describe the path of alongshore currents in the Yellow Sea.

Figure 9 shows that the horizontal distributional trends derived for bottom-layer transmittance during the two surveys are basically identical.

Within the cold water mass, the transmittance of the seawater in the northern part of the southern Yellow Sea is better than that of the seawater in the southern part and the transmittance of the seawater in Haizhouwan Bay is good, while the seawater along the shallow beaches of northern Jiangsu and far-sea areas off Chengshanjiao is extremely turbid. Another important characteristic of the distribution of transmittance is that a turbid water tongue running south along the cold water mass front exists in the outer sea of Chengshanjiao and Shidao Island. This water tongue is narrow at its origin but gradually broadens as it passes by the eastern part of the peninsula. This characteristic indicates that the alongshore currents are quite strong at the beginning but their rate of flow gradually diminishes afterwards. The seawater gradually clears up when the water tongue reaches 36°N and the turbid water tongue disappears. Replacing it is another clear water tongue that flows southward along the cold water mass front outside the mouth of Haizhouwan Bay. For this reason, it can be stated from another perspective that the distribution of transmittance in Yellow Sea indicates that a marine current exists which flows southward along the cold water mass front in the western part of the Yellow Sea. It must be pointed out that the flow images plotted from transmittance data are identical to the results of dynamic calculations, which indicates that the alongshore currents in the Yellow Sea during the summer basically assume a state of geostrophic equilibrium. In Figures 9a and 9b, one also can note that the distributions of transmittance in the bottom layer of the cold water mass front during the summer and fall differ mainly in that: because the boundary of the cold water mass is very close to the coast during the summer, the corresponding turbid water tongue and clear water tongue along the cold water mass front distribution lie slightly nearer to the coast, while the cold water mass boundary retreats seaward during the fall. For this reason, the turbid water tongue and the clear water tongue distributed along the front described above migrate seaward somewhat. On this basis, we can deduce that from the end of summer to late fall, the disappearance of the cold water mass also leads to a corresponding seaward migration of the path of the Yellow Sea alongshore currents.

Figure 9. Horizontal Distribution of Bottom-Layer Transmittance



a. July 1984 b. November 1983

Dark lines indicate the position of bottom-layer cold water mass fronts at the time of the survey

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12539/7358

ISOLATION AND IDENTIFICATION OF MARINE LUMINOUS BACTERIA FROM WATERS OF HUANGHAI SEA (YELLOW SEA)

Beijing HAIYANG YU HUZAO [OCEANOLOGIA ET LIMNOLOGIA SINICA] in Chinese Vol 18 No 4, Jul 87 pp 333-340

[English abstract of article by Shen Jianwei [3088 1696 0251], et al., of East China Normal University, Shanghai]

[Text] Eighty-four strains of marine luminous bacteria from seawater, sea mud, surfaces and intestines of fish as well as other sea animals of the Huanghai Sea were submitted to an extensive physiological, nutritional and morphological characterization. Seventy items were tested. A numerical analysis of the results grouped these strains and other types or previously characterized strains into eight clusters which were formed based on their overall phenotypical similarity. The identified strains were grouped into three clusters which contained the type or previously characterized strains of the species Photobacterium leiognathi, Vibrio fischeri and V. harveyi. The similarity was determined using Sokal and Michener's simple matching coefficient (S_{SM}). The single-linkage method was used in grouping, while FORTRAN was used in the computer program.

Antigenic determinant divergence of superoxide dismutases (SODs) from six respective strains of the three clusters was determined by the Ouchterlony gel double diffusion procedure. The results are as follows: six strains of bacteria could be divided into two groups, respectively belonging to the genus Vibrio and Photobacterium. In addition, the latter group could be divided into two further subdivisions--the species P. leiognathi and P. phosphoreum. These were in agreement with the results of numerical analysis. The SOD activity was measured by a progressive chemiluminescence method. The three clusters were readily identified as Photobacterium leiognathi, Vibrio harveyi and V. fischeri. The three species were first found in the waters of the Huanghai Sea. Since only one strain of V. fischeri had been found in China, it is of significance that many strains of V. fischeri were obtained in the study. It shows that V. fischeri is an extensive species in all sea waters on the earth.

The characteristics of the strains of V. fischeri presented in the study include the following: all of the strains are of the same variety of flagellation (3-8 flagella at one or both poles), they largely produce yellow

pigment, are not able to grow at 35°C and most of the strains utilize alginate, acetate, DL-malate, aconitate and L-threonine as their source of carbon and energy, while some of them utilize mannitol as this source, differing from the strains studied previously.

Another discovery has been made in this study. When the V. fischeri bacteria could not produce yellow pigment the vitality of the bacteria dropped, the cell colony became very small and bioluminescence was weak and, conversely, when the bacteria could produce yellow pigment the vitality of the bacteria was very strong, the cell colony became very large and bioluminescence was powerful. It is inferred that yellow pigment plays a significant role in maintaining the functions of the cell membrane. Perhaps the yellow pigment can someday be used as a drug to strengthen people's vitality.

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MEASUREMENT OF OCCURRENCE FREQUENCY, INTENSITY AND DURATION OF WIND-WAVE BREAKING

Beijing HAIYANG YU HUZAO [OCEANOLOGIA ET LIMNOLOGIA SINICA] in Chinese Vol 18 No 4, Jul 87 pp 380-387

[English abstract of article by Xu Delun [1776 1795 0243] of Shandong College of Oceanology, Qingdao]

[Text] Wind-wave breaking plays an important role in all aspects of air-sea exchange processes, including moment, heat and mass. Breakers also initiate a number of oceanographical phenomena, such as whitecaps on the sea surface, bubbles in the near-surface ocean and spray in the atmospheric boundary layer. However, wind-wave breaking has rarely been measured directly and quantitatively studied due to various difficulties. As a good start toward quantifying wind-wave breaking, Longuet-Higgins and Smith (1983) designed a surface meter to measure the occurrence frequency of wind-wave breaking in the open sea.

The present study refines and develops the method mentioned above to include measurements of intensity and duration of wind-wave breaking.

Suppose that $\eta(t)$ is a time series of sea-surface elevation measured in a fixed point and $R(t) = \frac{\partial}{\partial t}\eta(t)$ is its temporal derivative. If a breaking wave passes by the point, there would be a jump in $\eta(t)$, or a sudden increase in $R(t)$, which is called the surface jump (Longuet-Higgins and Smith, 1983). The extreme surface slope of a regular gravity-progressive wave derived by Longuet-Higgins and Fox (1977), $S_{max} = 0.586$, is used as a criterion of wind-wave breaking. The individual wind-wave wave is defined by up-zero crossings, and its phase velocity c is calculated approximately from the dispersion relation of the Stokes wave (to the second order):

$$c = \frac{gT}{2\pi}[1 + k^2(H/2)^2], \quad k = \frac{4\pi}{gT^2}$$

Therefore, the critical value of the temporal derivative of the sea surface is $R_{max} = 0.586c$. For individual wind-wave waves, c is different, as is R_{max}. Each individual wave, therefore, has its own breaking R_{max}. If $R(t) \geq R_{max}$ along a wave surface, even for a short time, the wave is classified as a breaking wave.

Let n denote the number of breaking waves in a sufficiently long record $\eta(t)$, and N denote the total number of waves in the same record, then P = n/N is defined as the occurrence frequency of wave breaking.

The jump height of the sea surface, J_h, is defined as

$$J_h = \int_{t_r}^{t_f} R(t)dt = \eta(t_f) - \eta(t_r),$$

where t_r and t_f are, respectively, the same distances when R(t) rises and drops below the criterion R_{max} during the same wave period.

The jump duration of the sea surface, J_d, is defined as the period during which the surface slope keeps exceeding the critical value 0.586, that is

$$J_d = t_f - t_r.$$

Obviously, J_h and J_d are measures of intensity and duration of wave breaking, respectively.

The mean jump height J_h and mean jump duration $\bar{J}_d$ averaged over breaking waves are defined as

$$\bar{J}_h = \frac{1}{n}\sum_{i=1}^{n}[J_h]_i$$

and

$$\bar{J}_d = \frac{1}{n}\sum_{i=1}^{n}[J_d]_i$$

The total mean jump height $\tilde{J}_h$ and total mean jump duration $\tilde{J}_d$ averaged over the total number of waves are respectively defined as

$$\tilde{J}_h = \frac{1}{N}\sum_{i=1}^{n}[J_h]_i = P\bar{J}_h$$

$$\tilde{J}_d = \frac{1}{N}\sum_{i=1}^{n}[J_d]_i = P\bar{J}_d$$

where J_h and J_d are taken to be zero for unbreaking waves.

Measurements were conducted in a wind-wave tank. Capacitance-type probes were used to measure the surface elevations $\eta(t)$ at fetches of 10.0, 15.1 and 20.4 m under wind speeds from 5-16 m/s, and the finite differencing was used to compute R(t). The variation of the occurrence frequency of wave breaking, P, is plotted against wind speed U. The nondimensional quantities $\bar{J}_h/\bar{H}$, $\bar{J}_d/\bar{T}$, $\bar{J}_h/\bar{H}_b$ and $\bar{J}_d/\bar{T}_b$ are plotted against U. Comparing the results measured in the tank directly and indirectly with those obtained by Longuet-Higgins and Smith (1983), Weissman (1984), Duncan (1981) and Monahan (1969) shows good rationality of the definitions and method proposed above.

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CLUSTER ANALYSIS OF WATER MASSES IN EAST CHINA SEA IN SUMMER 1984

Beijing HAIYANG YU HUZAO [OCEANOLOGIA ET LIMNOLOGIA SINICA] in Chinese Vol 18 No 4, Jul 87 pp 388-395

[English abstract of article by Miao Yutian [5379 5148 3944], et al., of the Second Institute of Oceanography, SOA, Hangzhou]

[Text] The authors used the Kuroshio experiment investigative data in the East China Sea during summer 1984, adapted the included angle cosine method of the Q-type in cluster analysis and, by computing a similar matrix, made water mass classifications from the temperatures and salinity of 82 stations. They discuss the characteristics of the water mass distribution status and cluster results on the surface, 10 m, 100 m layer and F section. The water masses are divided into five kinds in the second stage: the surface kuroshio water of high temperatures and high salinity located on the right side of the observation area; the Taiwan warm surface water with a high temperature and higher salinity water mass which expanded toward the northeast, tongue-like, along a 50-100 m isobath, with its tongue-peak reaching nearly 30°N; the coastal water of the East China Sea which mainly consists of the runoff Changjiang and Qiantang rivers and is mixed up with adjacent waters (it is a coastal water of low salinity); the continental shelf modified water mass--a complicated mixture of the three kinds of waters mentioned above, occupying a large part of the observation area; and a small part of the surface water in the Huanghai Sea in the northern section of the observation area. The cluster analysis types of water masses below the surface are similar to those of the surface layer.

The cluster analysis results coincide with those found by the T-S diagram method and geostrophic flow. Therefore, the method described in this paper has been introduced. If other index values are available in addition to temperature and salinity (data unfortunately not gathered by the authors), a theory will be derived using more than two-dimensional cluster analysis.

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ANALYSIS OF CHARACTERISTICS OF MULTIFREQUENCY OSCILLATION OF KUROSHIO BETWEEN TAIWAN AND IRIOMOTE-SHIMA

Beijing HAIYANG YU HUZAO [OCEANOLOGIA ET LIMNOLOGIA SINICA] in Chinese Vol 18 No 4, Jul 87 pp 396-406

[English abstract of article by Chen Shangji [7115 0006 0644], et al., of the Institute of Marine Scientific and Technological Information, SOA, Tianjin]

[Text] Based on the data of moored Aanderaa current meters near the Kuroshio path between Taiwan and Iriomote-Shima gathered by Tokai University, Japan, the harmonic analysis of the tidal current and the spectral analysis of the current, temperature and salinity of the seawater are made in this paper. The results show that, in addition to the obvious mid-frequency oscillation, i.e., the tidal fluctuation, there exist various low-frequency oscillations, with periods from a few days to more than 10 days. After using significant tests involving the maximum entropy spectrum, the authors found that the low-frequency oscillations were more significant, with powers three to five times those of the diurnal tidal constituent, next only to the semidiurnal one. In addition, in the low-frequency section, the coherence between any two levels is notable. Through the analysis, the authors have obtained a brief sketch of the velocity structure, the characteristics of multifrequency oscillation and the features of variation of the Kuroshio to the east of Taiwan.

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GENETIC AND PHENOTYPICAL SUPPRESSION OF OUTER MEMBRANE MUTANT ompD IN ESCHERICHIA COLI

40091003 Beijing YICHUAN XUEBAO [ACTA GENETICA SINICA] in Chinese Vol 13 No 4, Aug 86 pp 243-247

[English abstract of article by Chao Qimin [1560 7784 2404], et al., of the Institute of Genetics, Fudan University, Shanghai]

[Text] The rifampicin-resistant mutants of the outer membrane protein mutant ompD strain FD2003 have been shown to be reversed when growth at nonpermissive temperatures is involved. The suppression effect of the rif^R mutations has been confirmed through P1vir transduction. The rif^R mutations have been mapped at the rpoB locus, 89 minutes on the genetic map of E. coli. In addition, phenotypical reversion of the ompD caused by streptomycin and a high concentration of NaCl is observed. (Received 30 Jul 85. Project supported by the Science Fund of the Chinese Academy of Sciences.)

9717

ANALYSIS OF TRANSLATION PRODUCTS OF RIBOSOMAL GENE MUTANTS IN BACILLUS SUBTILIS

40091003 Beijing YICHUAN XUEBAO [ACTA GENETICA SINICA] in Chinese Vol 13 No 4, Aug 86 pp 248-253

[English abstract of article by Zhou Fen [0719 5358], et al., of the Institute of Genetics, Chinese Academy of Sciences, Beijing]

[Text] The translation products of ribosomal protein gene mutants in Bacillus subtilis have been analyzed by means of pulse-chase labeling the protein in vivo with radioactive amino acid and by using two-D(IEF/SDS-PAGE) gel electrophoresis and fluorography. Differences in the electrophorograms of variant strains have been found. These differences involve an increase or decrease in the relative amount of some proteins, and the appearance or disappearance of new proteins in the electro-pherogram. These variations have also been observed in mutants which have a different alteration of the same ribosomal proteins, as well as in the same mutants during different labeling time periods. All of the results refelct the complexity of the influence of translation for ribosomal protein gene mutations in Bacillus subtilis.
(Received 21 Oct 85.)

9717

VIRUS TRANSMISSION AND GENETIC RECOMBINATION FOLLOWING INTERSPECIFIC PROTOPLAST FUSION IN ASPERGILLUS. II. HYBRIDIZATION BETWEEN A. NIGER AND A. ORYZAE

40091002 Beijing YICHUAN XUEBAO [ACTA GENETICA SINICA] in Chinese Vol 14 No 2, Apr 87 pp 127-134

[English abstract of article by Liang Pingyan [2733 1627 1750], et al., of the Institute of Microbiology, Chinese Academy of Sciences, Beijing]

[Text] Interspecific protoplast fusion between virus-infected species A. niger, a glucoamylase producer, and virus-free species A. oryzae has been carried out. Two morphologically different hybrid types were obtained from the fusion product. Hybrid I was found to be diploid by means of genetic and biochemical analysis, while Hybrid II produced no conidia and grew slowly.

Detection of the virus in hybrids and their progeny showed that the two hybrids and seven of eight segregants, including the parental A. niger species conidia, contained virus particles similar in morphology, serological properties, coat proteins and viral RNA to those found in the initial virus-infected species. One segregant, however, and one isolate from heterokary produced the parental A. oryzae conidia (bro, leu$^-$). In this experiment, after the fusion of the cytoplasm and the subsequent fusion of nuclei followed by haploidization during the parasexual reproductive process, the progeny producing A. oryzae conidia remained virus free, although one of the parents and the nybrids were virus infected. Such parental segregation indicates that virus transmission from virus-infected species to virus-free species is not due to simple cytoplasmic inheritance, but is conditioned by a nuclear element. This element is recessive as evidenced by the presence of the virus in the diploid hybrid.

Although in Aspergillus hybridization can be obtained following interspecific protoplast fusion within the A. nidulans group or between the A. nidulans group and A. fumagatus group, no data are available so far concerning virus transmission through interspecific hybridization. In this report, crosses between A. niger (A. niger group) and a distantly related species A. oryzae (A. flavus group) are described, and the detection of the virus transmission and a comparison of the glucoamylase product in the parents, hybrids and progeny are presented. (Received 28 Apr 86.)

9717

COMPARISON OF CHROMOSOMAL ABERRATION INCIDENCE IN PERIPHERAL BLOOD LYMPHOCYTES OF DOGS EXPOSED TO THERMAL BURN AND RADIATION

40091002 Beijing YICHUAN XUEBAO [ACTA GENETICA SINICA] in Chinese Vol 14 No 2, Apr 87 pp 149-154

[English abstract of article by Bai Yushu [4101 3768 2579], et al., of the Industrial Hygiene Laboratory, China National Center for Preventive Medicine, Beijing]

[Text] Healthy adult dogs of 13-25 kg were used in this study. They were divided into three groups: The first one was simply irradiated with various doses (1-5 Gy) of ^{60}Co gamma-rays in vivo. The second was exposed to the same dose of gamma-rays in vitro, and the third was exposed to the same dose of gamma-rays but in combination with 15 percent second degree burns. The incidence of chromosomal aberrations in the dogs' peripheral blood lymphocytes was examined. The chromosomal aberration incidence among the three groups was similar, with no significant differences. By regression analysis it is shown that not only were the models the same, but also the regression equations of the same indicator among the three groups were almost equal.

The above results show that the combination with 15 percent second degree burns did not affect the incidence of chromosomal aberrations induced by gamma-rays in the lymphocytes, so the incidence of chromosomal aberrations of lymphocytes can still be used as a biological dosimetry for individuals afflicted with radiation-burn injury. (Received 9 Dec 85.)

9717

PREPARATION OF HCG AND HLH ANTIBODIES AND THEIR CLINICAL APPLICATION

40091001 Beijing SHENGZHI YU BIHUN [REPRODUCTION AND CONTRACEPTION]
in Chinese Vol 7 No 1, Feb 87 pp 15-19

[English abstract of article by Lu Weizhao [4151 1919 6856] of Shanghai Institute of Planned Parenthood Research; Eric Wong and Chi-Yu Gregory Lee of the Andrology Institute, University of British Columbia, Vancouver, Canada]

[Text] Monoclonal antibodies to hCG and LH were generated by a facile hybridoma procedure involving the use of a semisolid medium. Out of 272 hybrid cell lines, those that had a secretion of antibodies reacting with hCG, hCGβ-4D6 ($K_a = 1.2 \times 10^{10}\ M^{-1}$) and hCGαβ-IEO ($K_a = 8.7 \times 10^{8}\ M^{-1}$) were selected for the preparation of hCG immunoassay kits. Out of 43 hybrid cell lines, those that had a secretion of antibodies reacting with LH, LH15 ($K_a = 6.7 \times 10^{9}\ M^{-1}$) and LH48α ($K_a = 0.5 \times 10^{8}\ M^{-1}$) were selected for the preparation of LH immunoassay kits. Radioimmunoassay (RIA), solid-phase immunoradiometric assay (IRMA) and solid-phase enzyme immunoassay (EIA) were designed to measure the concentrations of hCG and LH. The sensitivities of the hCG and LH assay kits were determined to be 3 MIU/ml and 2 mIU/ml, respectively. The LH surge for women with normal menstrual cycles could be detected easily from urine specimens by a 30 minute procedure. In order to minimize the cross reaction to other competing hormones, LH130 was added to the hCG immunoassay kit and hCGβ-4D6 to the LH assay kit. As a result of this formulation, hCG and LH can be assayed using different kits with very little mutual cross reaction.

9717

STUDY OF TREATMENT OF PLASMODIUM CYNOMOLGI INFECTIONS OF MACAQUE WITH KETOTIFEN

40093042 Beijing YAOXUE XUEBAO [ACTA PHARMACEUTICA SINICA] in Chinese Vol 22 No 6, 29 Jun 87 pp 409-412

[English abstract of article by Huang Wenzhou [7806 2429 3166], et al., of the Institute of Parasitic Diseases, Chinese Academy of Preventive Medicine, Shanghai*]

[Text] Ketotifen 0.7-20 mg/kg x 3 days was given orally to P. cynomolgi infected Macaca mulatta. The asexual parasites and gametocytes in the blood were eliminated with 93-102.5 hours and 102.5-120 hours following administration, respectively. When chloroquine 12 mg/kg x 3 days was given, however, parasites disappeared in 66 hours. No effect on the tissue stage of this parasite was observed. If ketotifen 0.1 mg/kg x 3 days was given in combination with sulfadoxin (SDM') 5 mg/kg x 3 days, the asexual parasites and gametocytes disappeared in 79.5 and 153 hours, respectively, after administration, indicating a synergistic action between these two drugs. No side effects were observed during the treatments.

During the 30 days following observation, in one of the two monkeys treated with 5 mg/kg x 3 days and two monkeys treated with 1 mg/kg x 3 days ketotifen recrudescences of the blood parasites emerged.

The results show that ketotifen is a new chemical structure type and effective anti-simian-malarial drug, and observation of its antimalarial effects against human malaria is being undertaken.

* WHO Collaborating Center for Malaria, Schistosomiasis and Filariasis

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SYNTHESIS OF TRIFLUOROMETHYL AMODIAQUINE ANALOGS AND ANTIMALARIAL ACTIVITY

40093042 Beijing YAOXUE XUEBAO [ACTA PHARMACEUTICA SINICA] in Chinese Vol 22 No 6, 29 Jun 87 pp 413-419

[English abstract of article by Hu Hong [5170 4767], et al., of the Institute of Parasitic Diseases, Chinese Academy of Preventive Medicine, Shanghai*]

[Text] In searching for new effective antimalarial agents against both chloroquine-sensitive and chloroquine-resistant strains of P. berghei, eleven 4-(3'-alkylaminomethyl-4'-hydroxyl-phenylamino) and 4-(3',5'-bis-alkylaminomethyl-4'-hydroxyl-phenylamino)-7-trifluoromethyl-quinolines and eleven 4-(3'-alkylaminomethyl-4'-hydroxyl-phenylamino)- and 4-(3',5'-bis-alkylaminomethyl-4'-hydroxyl-phenylamino)-2-methyl-7-trifluoromethyl-quinolines have been synthesized and screened for their antimalarial activities.

The title compounds were prepared in the following way: 1. Mannich reaction of p-acetylaminophenol with formaldehyde and amines. 2. Hydrolysis of the acetyl group. 3. Ullmann reaction of the newly-formed amino compound with 4-chloro-7-trifluoromethyl-quinoline (I_0) or 4-chloro-2-methyl-7-trifluoromethyl-quinoline (II_0). They can also be obtained through the Ullmann reaction of p-aminophenol followed by the Mannich reaction.

Preliminary screening tests in mice infected with chloroquine-sensitive ANKA strain of Plasmodium berghei showed that 11 (I_{1-9}, $II_{3,6}$) of these compounds produced 100 percent suppression of the parasites when administered orally at doses of (20 mg/kg)/d x 4 and (10 mg/kg)/d x 4. Among them, three ($I_{2,6-7}$) suppressed parasitemia at (5 mg/kg)/d x 4. Two (I_4, II_3) of twelve compounds given orally at doses of (20 mg/kg)/d x 4 were shown to have three and four negative mice respectively out of each five mice infected with shloroquine-resistant ANKA strains of P. berghei, while amodiaquine presented no negative mice.

* WHO Collaborating Center for Malaria, Schistosomiasis and Filariasis

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NEW BOOK HIGHLIGHTS DEVELOPMENT, STATUS OF CHINA'S NUCLEAR INDUSTRY

40080007 Beijing RENMIN RIBAO (OVERSEAS EDITION) in Chinese 4 Sep 87 p 4

[Summary] The recently published book, "China's Nuclear Industry," is the first comprehensive, systematic publication dealing with China's independent research and development of atomic bombs, hydrogen bombs, and nuclear-powered submarines, as well as nuclear science and technology and the organization of the nuclear power industry.

The establishment and development of China's nuclear industry are closely tied to the development of its strategic nuclear weapons. Except for the announcements of successful nuclear tests in the past, everything else in the book on the above subjects is being published for the first time.

"China's Nuclear Industry" is the true story of the dedicated independent development of a nuclear industry by the Chinese people through their own initiative and self-reliance. The book cites a wealth of rare (valuable) archival materials and actual transcripts beginning with China's nuclear industry development from scratch to the rapid and successful breakthroughs in technology, the breaking of the nuclear monopoly, and subsequent rise to the advanced ranks of the world.

The book, with some 400,000 characters and accompanying illustrations and essays, is divided into three volumes. The first volume presents a step-by-step chronology of the establishment and development of China's nuclear industry, volumes two and three are devoted to the composition of the nuclear industry with a further breakdown as the professions and departments (organs). As a history of the Chinese nuclear industry, this book also lists notable scientists, experts, and other figures who have made contributions to this effort.

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TECHNICAL POST APPOINTMENT SYSTEM DISCUSSED

Editor's Note

40082111a Beijing KEJI RIBAO in Chinese 9 Apr 87 p 2

[Editor's Comment]

[Text] During the Fifth Session of the Sixth National People's Political Consultation Conference, many conference members who were from the world of science and technology suggested that this newspaper begin a "Science and Technology Policy Forum" so that science and technology personnel could express their opinions on issues of common interest and concern. Expression of different opinions may develop into a discussion or debate, thereby arriving at a consensus. This may play a role in enlivening thinking, exchanging viewpoints, channeling information and pooling collective wisdom.

We felt that this was a good suggestion and, therefore, are honoring our commitment by starting this column today. We eagerly hope that science and technology personnel will show an interest in this column, support it, submit manuscripts and actively present their opinions and suggestions, the more the better.

Continuity and Systematization

40082111b Beijing KEJI RIBAO in Chinese 9 Apr 87 p 2

[Article by Pei Lisheng, [5952 7787 3932] Member, Standing Committee, National People's Political Consultative Conference, Head of Science and Technology Group, Honorary Member, Chinese Science and Technology Association: "Continuity and Systematization of Technical Post Appointment System"]

[Text] Implementing the technical post appointment system is a major reform of China's technical personnel management system and of basic construction in socialist modernization. Currently, this work is taking place comprehensively in science and technology, education, and medicine and public health.

This post appointment system combines "responsibilities," "rights" and "benefits," and will be good for reforming lifelong employment, smashing the "iron rice bowl," promoting the sensible movement of talent, and reforming inappropriate mixes of talent.

In the year since implementation, this appointment system has achieved good results. It is widely supported by intellectuals. Since this is a new assignment system, it is an important part of the wage system reform and has profound significance. However, this is a wide-ranging and very difficult task. It is unavoidable that many new problems will appear in implementing it in local areas. We should not worry about the number of problems, for as long as we rely on the policies of the central committee and science and technology personnel, problems can always be resolved. Therefore, science and technology personnel hope that through constantly reforming and improving the science and technology appointment system, it will continually improve.

In implementing the appointment system in local areas, there is currently a problem of science and technology personnel "crowding onto the bus," which is caused by the following two factors:

1. Since wages and titles have been frozen for many years, science and technology personnel think this appointment work has solved this long unresolved problem.

2. For a long time post evaluation has not been standardized and, therefore, has not had continuity. People are generally worried that if they are not promoted this time, who knows when the next time will be and, therefore, they are doing everything they can to "crowd."

Systematization is the key to carrying out and realizing the continuity of this policy, but if this policy has no continuity it may affect people's confidence in it. Therefore, systematization of the technical post appointment system is extremely important. In view of this, I suggest that the central committee and the State Council release a clear announcement regarding this issue, and in accordance with the development of China's economy, formulate a system of annual or biennial evaluation of the professional qualifications of some of the science and technology personnel. This will play a beneficial role in calming the fears of the intellectuals and stabilizing the thinking of science and technology personnel.

To guarantee this continuity and systematization and mobilize all initiative, science and technology committees and planning commissions should organize relevant units to establish special science and technology grades for those science and technology personnel appointed, recommend talent for units, regions, and industries which urgently need science and technology forces and select technological personnel so that they can use their talents to the fullest and better serve the four modernizations.

Systematize Appointments

40082111c Beijing KEJI RIBAO in Chinese 9 Apr 87 p 2

[Article by Dai Chuanceng [2071 0278 2582], Honorary President of the China Atomic Energy Institute: "The Appointment System Should Truly Be a System"]

[Text] An appointment system combining specialist posts and titles will be good for the circulation of talent as well as for distribution according to work, thereby mobilizing people's initiative.

China's implementation of an appointment system has an active role, but there are some practical problems which must be studied and resolved to avoid negative influences.

(1) For the past 20 years the there have been many significant problems with post titles. Middle-aged persons in some old units have achieved high professional levels and made substantial contributions, so the number of people who should be appointed may be greater than the number of appointments available. If an appointment cannot be made, the opportunities for transfer to participate in an enterprise-type development unit are not extensive either, and it is difficult to resolve the issues of population, housing and education of children, thereby obstructing the normal circulation of talent. It is appropriate for units facing this situation to proceed from the viewpoint of safeguarding talent and adopt as many measures as possible which conform to the actual situation. Of course they should also exercise strict control.

(2) To take advantage of the "excessive enthusiasm" of second and third line specialists and for ease of social appointment, it would be appropriate to preserve their current titles, such as professor, high level researcher, and high level worker. This is beneficial to society and is also one way of respecting talent and knowledge. When necessary, such titles as retired, honorary and life-long can also be assigned. Of course, after the technology market is active, social welfare is complete and the legal system has been improved, it may not be necessary to do this.

(3) Formulation of some basic appointment conditions is necessary to avoid random numbers, but this should be based primarily on the higher level review within the industry to prevent ineffective work and the superficial nature of going after diplomas and studying foreign languages. We should not evaluate talent inflexibly in terms of actual ability and contribution, but should give prominence to the importance of review by members of the same field and encourage a spirit of seeking results through self-study.

(4) The four modernizations require a great number of high-level specialized personnel, but now, except for an extremely small number of old comrades who are hanging on to high-level posts [2909 2945] and job titles and salaries, there generally will be no way for their successors to be promoted. Low salaries and low posts and job titles limitations do not seem consistent with the policy of respecting talent knowledge. To mobilize the initiative of the middle-aged and young specialists, we should permit promotion to "high" posts. The state can increase expenditures for this, the amount of which cannot be too great.

Improvements for System

40082111d Beijing KEJI RIBAO in Chinese 9 Apr 87 p 2

[Article by Hu Min [5170 2404], Vice President, Planning and Design Academy, Ministry of Coal Mines: "The Appointment System Should Be Improved"]

[Text] Last year the State Council decided to revive the high-level technological titles review work which was stopped three years ago, and engineering and technological personnel all were elated. At the same time, they also decided to implement a technical post appointment system. This is a major reform which will be helpful in smashing the practice of considering qualifications and arranging ranks according to seniority and in reaching the point of selecting and using the best. It has been helpful in the sensible circulation of talent, encouraging people to use their abilities to the utmost, and aiding in studying hard for the four modernizations, doing all one can, and the engineering and technological personnel have supported it wholeheartedly. Regarding the experiment involving the coal system, it definitely played a role in mobilizing the initiative of intellectuals.

Since the post appointment system has just begun, from the tests it can be seen that two types of situations have appeared: one is that some comrades do their assessments from two aspects--morality and talent. It used to be that they should have been approved for high-level technical job titles, but because of limitations of the appointments ratio, they could not be appointed. The second is that individual comrades have been top-notch at work and also have made contributions, but for one reason or another it was difficult to approve them for high-level titles, so they could only be appointed to low-level posts. In a word, there was the problem of "many monks but little gruel."

My view is that comrades of the first type should be approved for high-level titles, but even if they are appointed deputy (or some other title), their's should not be included in the number of high-level posts, and they should receive only a part (or none) of the post's designated salary. Comrades of the second type should be granted assistant high-level titles, but appointed to low-level posts.

To this end, I propose that the state's "liberal policy" permit provinces (municipalities and autonomous regions) and ministries (committees), while guaranteeing quality of review and appointment work, to separate the posts, salaries and titles involving these comrades to suit the actual situation.

Consolidate Mainstay Ranks

40082111e Beijing KEJI RIBAO in Chinese 9 Apr 87 p 2

[Article by Qian Zhongtai [6929 6988 3141], Deputy Chief Engineer and Vice President, China Measurement Sciences Academy: "Consolidating Scientific Research Mainstay Ranks Is an Urgent Matter"]

[Text] Measurement work and standards work alike are basic technological tasks of the economy. For a variety of reasons it is now urgent that we have a scientific research mainstay rank to develop the state's technological foundation.

Almost all of the young comrades in our academy who have ability are preparing to undertake graduate study or go abroad. Those who are satisfied with their jobs are worthless. This does not apply only to the young, but a significant number of middle-aged science and technology personnel see going abroad as the best way of being productive. In addition to the fact that our salaries are low and that going abroad has great economic benefits, this also is directly related to China's policy of assessing science and technology personnel.

There is no question that the majority of Chinese who have gone abroad in the past were capable. Many Chinese who returned to China during the revolution and construction made great contributions. But we must take note of the fact that those who made up the main body of China's scientific research ranks and made the most important contributions were science and technology personnel who worked in China. To facilitate discovering and using those science and technology personnel in China with proven results and ability and to ensure working conditions conducive to their making rapid achievements, it is necessary to consolidate China's scientific research ranks.

I think that we need not overestimate the praise of foreign specialists for China's science and technology personnel. The science and technology personnel we have trained ourselves are industrious and capable. Sometimes it is very easy to obtain the praise of foreign specialists out of courtesy. However, if we feel that people who obtain this type of praise are the most capable among China's science and technology personnel, and that their contributions to the development of China's science and technology have been the greatest, then clearly we are mistaken. Some of our leaders and public opinion circles have an overly high regard for the opinions from abroad, indicating that China's science and technology leadership organs lack the ability to discriminate.

In order for science and technology personnel working in China to have the necessary opportunities for development, China should establish a suitable system as rapidly as possible to provide them with the opportunity to obtain academic degrees, and constantly improve the technological post appointment system and other relevant regulatory systems.

In particular, we should emphasize the advancement and training of young science and technology personnel with proven achievement. At present, the burden of science research missions has mainly shifted to their shoulders. Our measurement academy high-level post promotions are awarded basically according to seniority. Only one person who has graduated since 1966 has been promoted to a high-level post, and this is extremely abnormal.

The evaluation of titles and posts should be not only by diploma, but also should be determined by the actual ability to encourage self-improvement.

Post, Title Dual-Track System

40082111f Beijing KEJI RIBAO in Chinese 9 Apr 87 p 2

[Article by Xu Bowen [1776 0590 2429], Senior Engineer, Academy of Hydroelectric Sciences, Ministry of Water Conservancy and Electric Power: "Proposal For a Dual-Track System of Posts and Titles"]

[Text] After reviewing technical posts and implementing a new wage system based primarily on post wages, definite results were obtained. However, since much consideration was given to the negative role which can result from technical titles, with too little consideration being paid to its inherent positive role, the technical titles in the new wage system were treated as technical posts, while the titles were actually eliminated. Many problems have arisen since this method was implemented, with the views of science and technology personnel being prominent and, therefore, the existence of technical titles must be acknowledged individually and gradually in practice. Under these circumstances, I believe that we should implement a dual-track system of posts and titles as quickly as possible to benefit the development of the strong points, thereby avoiding the shortcomings. The reasons are as follows:

1. Title and post are two different concepts. Post refers to the work of the post, the responsibilities therein, and the merits, accomplishments and contributions, therefore it should be linked to wages and authorized strength quotas. However, the title is a combination of the technical level, work ability, merits, accomplishments and contributions (including current merits and accomplishments and past contributions). Therefore, it is primarily honorary and is not subject to the limitations of post or authorized strength. Its greatest advantage is that it encourages science and technology personnel to make an effort toward further study involving scholarship and technology, thereby making a greater contribution.

2. A technical title is not the same thing as academic record and rank. Academic records, academic degrees and academic rank only indicate the level of scholarship and technical ability; however, a technical title records merits, accomplishments and contributions, representing work undertaken in the past and the accomplishments contributed. This is why science and technology personnel place more stock in titles than in posts. Only by understanding this mentality of intellectuals can one understand the important function of acknowledging titles.

3. The act of treating titles, academic degrees and rank equally and viewing titles as posts will necessitate the determination of authorized strength. If the authorized strength is determined to be more, then the number involved will only need to be increased. However, if the authorized strength is determined to be less, then it will hinder the growth of new forces. This is the issue of most concern to science and technology personnel at present.

4. If only the limitations involving term of appointment and current work required by the post are considered in linking posts to wages without bearing in mind the responsibilities of the post, then, in principle, there are no

definite wages for this post. This is compensation according to work, which is correct in principle. But for titles which take into consideration past merits and accomplishments, this involves an overall evaluation and a matter of credit. And this is indispensable. Therefore, in addition to enjoying resignation and retirement benefits, technical cadres who have resigned or retired should also be granted titles. Abroad, such titles exist as retired professor and honorary professor; in China, high-level titles which were reviewed in the early period received a certificate issued by the state science and technology cadre bureau which granted recognition--this would solve the problem. I propose that such a system be established from now on.

5. A system of titles benefits encouraging scholarly research and scaling new heights, while post wages are also beneficial in this regard. From the viewpoint of the post, high-level posts cannot be filled over strength; however, from the viewpoint of titles, if the proportion of high-level titles in a unit is great, and there are many individuals, a high level is indicated. This is good, and a method which would encourage the formation of a "national corps" in a specialization similar to those in sports would be good for science and technology attacks on key problems.

6. Implementing only a single-track post system and not, at the same time, implementing a dual-track post and titles system is not good for the circulation of talent, nor for guaranteeing that high-level titles will assist units which do not have authorized high-level post strength, especially in helping border area, poor regional and small town enterprises, and in sparking plans which are old and undermanned.

7. Compared to the professor, researcher, and physician series, the engineer series involves even more problems. This is due to the fact that, in the new wage system, the engineer series does not include the post of senior engineer. In a note it says only that engineers of past levels three to nine may temporarily be treated as chief or deputy engineer depending on proximity. They are currently called "high-level engineers"; but in terms of authorized strength there should be fewer chief and deputy engineers. If this situation is not changed, there will be more problems, and this is not sensible. In addition, high-level engineer is a grade corresponding to professor and assistant professor, researcher and assistant researcher, which does not make sense. It should instead be changed to chief and assistant grades. The current method requires that the old grades of the old system be drawn upon when it is necessary to divide the grades, and this is not appropriate.

8. Since implementation of the post wage system in the reform of titles, with the titles being treated as posts, the title system has been stopped, with many problems appearing during execution. If a technical leadership post appointment is a high-level post, it fills up a quota, inviting extensive mass opinion. However, if it is not an appointment as a high-level post, at the end of tenure there is no quota position to be appointed. If the title is changed the problem is solved, but society has now become accustomed to the titles President So-and-so or Professor So-and-so, with the former being a post and the latter a title. Or again, if a certain post requires a specialized cadre from within the enterprise but who cannot be appointed to a technical post, such as party committee secretary or personnel director, he can keep the technical title and undertake the post.

9. In implementing the post wage system, technical posts require a method to evaluate the title, i.e., evaluating the thesis, reviewing results, testing foreign languages, etc., but for administrative and management cadres it is just a matter of appointment. Moreover, in the wage system, high-level engineers are equivalent to directors, while engineers are only equivalent to section chiefs. What this objectively encourages is becoming an official and not advancing one's learning.

The above situations indicate that there still are some practical problems with the titles in the post wage system already implemented and, therefore, it would be advisable to implement a dual-track system of titles and posts as quickly as possible.

Suggestions for Title Reform

40082111g Beijing KEJI RIBAO in Chinese 9 Apr 87 p 2

[Article by Liao Yanxiong [1675 1693 7160], Professor and Honorary President, Jiangxi Academy of Sciences: "Some Suggestions for Implementing Title Reform"]

[Text] Implementing the post appointment system involves making the appointment after the title has been evaluated. Responsibilities after appointment need to be clarified and linked with wages. This is not a life-long system, but it has its good points and should be continued. However, I have a few suggestions:

1. Improve standards--Standards have been agreed upon for titles at various levels, but they have not been perfected and should be strengthened in implementation. For example, (1) in the scientific research series, eliminating such graduates as senior specialist and mid-level specialist from the scientific research series is both unfair and not appropriate to actual circumstances. Scientific research personnel who have the qualifications to be promoted, but do not have an adequate education or lack an academic record, could be promoted after examination and review; (2) review of standards should be more specific to facilitate implementation, e.g., the foreign language requirement can be very clearly stipulated.

2. Operate on an annual basis: Promotion of titles (such as from teaching assistant to lecturer) and the dissemination of titles (if teaching assistant wages are divided into three grades, this would include wages from the lowest level to higher levels within the same title) definitely should be normalized. This was not the case last year when it went by fits and starts--if you didn't get on this bus, there was no telling when the next one would come along. Therefore, when one came, everybody tried to crowd on, and even when the doors were crammed full they still tried to get on, climbing over each other, comparing one's own superiority in a certain area to others' shortcomings. In my view, promotion of titles and grades of wages for titles at the same level should be normalized and carried out on a year-by-year basis. Zhang San didn't make it this time, but if he works hard he has a chance next year, which is good for both stability and unity as well as for mobilizing the initiative of working personnel. Concerning the financial problems if this is

done yearly, we cannot spend several hundred million each year, so will two or three hundred million suffice yearly? We have not carried this out for a number of years so there is great pressure and, of course, there will be difficulties.

3. Simplify levels and execute them according to standards--the present method is too complex. Some science and technology personnel say, "Every year there are some changes in director, scientific personnel, office chief, bureau chief, minister...and all are linked to wages; being appointed isn't complicated, but can appointment of science and technology personnel be simplified like that of administrative cadres?"

My view is: formulate better standards and operate strictly according to these standards. After unit review (the review committee members can be invited from another unit), the unit decides whether or not to make the appointment. They are controlled by the total amount of wages and authorized strength. If the unit does not exceed authorized strength or total wages, they can appoint from among personnel who meet the qualifications.

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RESEARCH INSTITUTE REFORM REPORTED

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[Article by Li Minquan [2621 3046 2938], Machine-Building Industry Committee, Shanghai Cable Institute: "A Direction For Reform in Research Institutes: Technical Development Centers"]

[Text] Abstract: This paper is a scientific analysis of the mission, source of funds, and organizational form of research institutes after readjustment and transformation based on a pilot project realigning this institute as a technical development center. It concludes that the technical development center is a direction which can be taken for reform of independent development research institutes. It assumes that research on projects which are applicable industry-wide and are important technologies, organization and coordination of technological services and administration, and quality control, verification, arbitration and supervision of products will greatly improve the integration of scientific research and production. However, to create a "center" with these functions still requires a process of readjustment and expansion.

Reform of the economic and science and technology systems has spurred a number of research institutes engaged primarily in technical development to consider their options. This is particularly true of those independent research agencies which have been subordinate to ministry committees and local leadership, and how to readjust and transform them in order to better integrate science and technology and the economy is an important part of the present science and technology system reform.

The following choices are available:

to continue to be an independent research institute and serve as a "national corps" of that discipline or specialization;

to gradually join an industry and become a technical development section of an enterprise;

to merge with an enterprise so that it becomes an intermediate test base and the first promotion station for new technology of a research institute;

to develop its own laboratory and become a production-type scientific research unit;

to be readjusted and expanded, expanding its functions so that the research institute becomes a technical development center, etc.

Under the general guiding principle that work in science and technology must be closely integrated with economic construction, the path for research institute reform should proceed from the actual practice of industry characteristics and the research institute itself, should permit a process of knowledge and practice, and should avoid purely administrative orders and proceeding in a rigidly unified fashion. This paper presents some views based solely on the conclusions drawn from a pilot project which readjusted and expanded a cable research institute into a cable industry technical development center.

I. The Cable Research Institute is a specialized research institute under the leadership of the machine-building industry committee. It includes specialists in such areas as electric wire and cable products, raw materials, industrial processes, special equipment, and plant and processing design, incorporating the corresponding research, design, testing, and technical information agencies. It was established in 1957 and now has fixed assets of 18 million yuan and a staff of 740.

The electric wire and cable industry has over 1,000 plants, more than 200,000 employees, a gross annual output of 7 billion yuan, and annual profits of about 1 billion yuan. Most of these plants are under the leadership of the machine-building industry committee, but some are under the leadership of the Ministries of Posts and Telecommunications, Petroleum Industry, Communications, and Electronics Industry. In 1983, the Cable Research Institute began trial work on readjustment and expansion into a technical development center. In the past three and one-half years, it has primarily done the following:

(1) Conducted technical and economic analyses of the industry and formulated technical development plans:

Each year a plant manager's meeting is held which produces a technical and economic analysis of the entire industry, including a list of plants arranged by such indicators as gross value of production, profits, labor productivity, rate of profits and taxes on funds, and energy consumption, and reporting such guidelines for development and forecasting as development and demand for products, production of raw materials and their applications, and the renewal and transformation of special processing equipment.

(2) Organized attacks on major technical problems in the industry:

Based on the common problems presented at the plant manager's meeting, the major technical projects were selected and relevant key attacks were organized for the various plants. In the past 3 years, 44 projects have been proposed and 24 have been completed.

(3) Organized the assimilation and absorption of imported technology and equipment:

In the past few years the electric cable industry has imported technology and equipment worth about $150 million. The "Center" arranged for various plants to participate in the study and exchange of this foreign advanced technology, and selected key items for further assimilation.

(4) Improved construction of a testing base:

The research institute serves as a testing base and has already passed qualifications review and approval of the state verification committee in line with product verification demands. Therefore, there is a supervisory, arbitration, evaluation, and verification unit on which the state can rely to ensure the quality of the industry's products. It has taken on the responsibility from state agencies for the inspection and supervision of the industry's quality.

(5) Accelerated the revision and formulation of standards:

It adopted international standards and drafted technical plans and measures for the industry, and also provided corresponding standards for the purchase of materials needed for electric cable products.

In addition, it also started work in the following areas: it organized the industry's information system so that it was wider and more active, and so that the information provided not only covered a greater area, but also was of higher quality; it trained specialists for the industry; to improve the quality of management in the industry's plants, it organized a quality control association, employee education cooperative network, a safety education network, equipment management association, and energy-saving association so that the industry's management systems had a forum for professional exchanges in order to improve the level of operation.

The plant managers recognize that, during the past 3 years, the electric cable industry's technical development center has developed and extended the functions of the original research institute. It relies on the industry, is oriented toward the industry and serves the industry, gradually becoming the organizer of the industry's technical core and technical progress. To a certain degree, it has broken free of the situation in which each enterprise struggled alone, and is welcomed and supported by the plants.

II. In whatever manner the organizational structure of the science and technology system is reformed, and whatever readjustments, transformations or new projects scientific research agencies carry out, the goal is to promote the integration of science and technology and the economy in order to meet the demands of the development of a socialist commodity economy. Therefore, only when the technical development research institute has intensified its technical development functions and earned the confidence of production sections through advanced and appropriate science and technology results, can it seek its own existence and development. The experiment involving the electric cable industry's technical development center tells us that through readjustment,

expansion and transformation, existing research institutes can play a major role in the technical progress of their industries. The directive involving the establishment of industrial technical development centers given by Premier Zhao Ziyang was entirely correct.

(1) Technical development includes both tactical projects and strategic content--research institutes should, therefore, expand their functions and contribute to these two important tasks.

The tactical projects primarily refer to major research and development work in the area of the industry's production. The demands for the development of new products, new processes, new materials and new equipment must, of necessity, include many key technologies which must be mastered. In order to maintain a plant's competitive advantage it is necessary to conduct research involving improving product quality and the processing level. Such projects are generally divided into long-term and short-term categories. In the past, the research institute primarily undertook tasks assigned by ministries and bureaus, most of which involved researching key technologies which had commonality, so although these technologies were also ones which were needed in industry product development, since they were not all of one kind, and since intermediate testing was lacking for some large-scale product research, the technology did not mature, making it very difficult to be promoted in large-scale industrial production. As a result, many people concluded that 60 to 70 percent of the technology used by large enterprises was self-developed, with medium-scale enterprises developing 50 percent of the technology themselves, and that research institutes did not play a large role in key industrial technical projects. The conclusions of this "Center" project show that the industry actually has vested great hopes in the research institutes for key technical projects. They hope that the research institutes will undertake the key projects which they do not have the strength to research, but they do not hope that the research institutes will compete with plants for topics at the same technical level. Therefore, the research institutes must accelerate the improvement of their own technical quality, dare to undertake and quickly master highly difficult key technologies and, at the same time, create the necessary intermediate testing and engineering design conditions so that results can really be applied in production.

Enterprisers are more concerned with the strategic development goals of their own enterprises, e.g., forecasting the market demand for goods, developing ways of transforming equipment and processes, selecting series of important goods and presenting their technical and economic analyses, investigating the present state of importing, assimilating and absorbing technology within the industry and preparing proposals for further plans, improving the level and supply channels of key raw materials, planning for enterprise transformation, etc. They hope that the industry's research institute will survey, study, analyze and promptly provide this type of report. In terms of plant manager's correct policy making, this type of report is more important than assisting in the resolution of a single technological key. The research institute should have the courage to undertake this type of strategic research task.

Technical development is not just hardware research on products, equipment, and materials. For many plants, sometimes development of "software" (i.e., management technology) is more important than hardware. At the development center

work conference, electric cable industry plant managers repeatedly asked that the technical development center also take charge of development of management technology. In the practical experience of plant managers, management technology has its common base of knowledge, but at the same time it also has its industry specifics, e.g., one can learn the theory of comprehensive quality control from a book, but the management systems and quality control methods of different leading products are not necessarily the same--there is a set of effective on-site management methods for the industry itself involving being strict regarding processing rules and intensifying processing management. However, mid-level cadres in different posts in the plants have a greater interest in the scientific management of technology, quality, equipment, and personnel matters. The "Center" pilot project has made encouraging progress in the organization and development of soft technology.

If the research institute can both storm the fortification of important technological key items and expand its service functions, advise the enterprise's strategic policy-making, and help plants improve their overall technical development ability, then the plants and the research institute will be like fish and water, and the development of the research institute will be solidly guaranteed.

(2) Obtain income by a variety of means and resolve the issue of technical development expenses.

Reform of the system for allocating research expenses is both a pressure on and the driving force for the research institute. In order to improve technical development ability, the technical development research institute must strive in every possible way to get contracts for important scientific research, development projects and construction projects for key laboratories and test bases which are in central or local plans in order to obtain central or local financial allocations. However, there are not many of these projects. In the technical development center of the electric cable research institute, in addition to obtaining income through such different channels as promoting technical contract systems, accepting commissions for research, transferring technical results, participating in joint technical investment ventures, consulting and accepting plant tests and measurements, some new methods have been found in the industry:

1. Raising funds to test manufacture the first special piece of equipment. Most electric cable production uses special processing equipment, therefore the emphasis on the plant's technical transformation is also placed on updating equipment. But the level and quality of the first piece of equipment developed cannot be forecast and, therefore, it is not sensible for one plant to undertake all the risks. At the same time, this is not good for technological progress either. The "Center" raised funds for this, with over 1 million yuan being raised from over 50 plants which was used to test manufacture the first piece of equipment. The funds were turned over: after the project was completed and the desired results achieved, the plants which used this equipment paid back the equipment expenses. In this way it also created conditions under which results were converted into productive forces for the research and design agencies.

2. Technical development projects which had commonality within the industry and were not directly competitive, such as technical and economic analyses not directed toward a particular enterprise, market forecasting, information, personnel training, domestic and foreign technical exchange, drafting of standards, and application of management technology research, were funded by the industry, with the results being shared across the industry. The electric cable industry plant managers were unusually in agreement, asking that the electric cable research institute be ranked an important task in its readjustment and expansion as the industry's technical development center pilot project. They divided the member units of the "Center" development system into a certain number of levels based on size, and they turned over 1,000-4,000 yuan per year in development expenses for these tasks.

3. The development of new cable industry products, processes, technologies, and materials has a direct bearing on the existence and growth of each plant. Technical contracts can be signed between the plant and research institute or between two plants and a willing source of capital. However, within the industry there should be a plan to avoid duplicate research as much as possible. If more than two plants have the need and, in terms of expenses, can also select the same project, then the industry's technical development center should organize several plants for joint research, with the expenses split and the results shared.

4. For basic technology involving high tech and important long-range science and technology projects, the state must be requested to expand enterprise autonomy, since, under the present system, enterprise autonomy is not great, reserved profits are too little, and the funds which can be used for research and development are insufficient. The expenses used annually for research and development by foreign cable enterprises reach, at the most, 6-8 percent, and even at the least 2-3 percent, of gross sales. If China can reduce, through taxes and profits handed over to higher levels, 1-2 percent of the gross value of production which would serve as funds for developing new technology and digesting and absorbing advanced technology imported from abroad to be used under unified planning within the industry, then there would be a source of scientific research expenses for use by the research institute for development of high tech products.

(3) There should be a voluntary, definite organizational form to benefit technical development, but it should not become the "mother-in-law" for each unit.

When the technical development center pilot project began, the plants were concerned that it would be just another new "mother-in-law." In practice, since the "Center" was to serve the industry but not change the original organizational system and jurisdictional relationship, it was not a substantial organization and each plant worried about its removal. In addition, the organizational looseness led to the problem of many tasks not being completed on schedule.

After three years of practice, plant managers feel that this project is beneficial for technical development and, on a voluntary basis, there should be a

definite organizational form. It was decided at the 1986 work conference that the plants would raise funds for common technical development projects and that a technical development system organizational committee would be democratically elected by the units raising the funds. Its responsibilities included: to lead the working body established within the "Center," use the funds raised, and study and decide policy involving issues of common concern to the industry. An organization subcommittee also can be established under the organizational committee based on the product, specialization or management to facilitate activity. In this way the cable industry nationwide formed a network-type organization within all areas of the industry in technology, management, administration and information. This organization has the following characteristics:

1. The organizational committee does not change the organizational system and jurisdictional relationship of the plants, and the enterprises (including research institutes) still administer and produce according to the expanded autonomy granted by the state, with no new "mother-in-law" restrictions. However, in terms of the entire industry, technical blockades are smashed and there are organizers for technical progress within the industry.

2. The industry has issues of common concern, e.g., technical progress and transformation, policy-making on product administration, and quality and price. Foreign industries frequently organize their own industry societies or associations, and communicate within the industry or seek countermeasures to protect common interests within the industry. The organizational committee created by the cable industry technical development center and its subordinate subcommittees can perform these association functions for the industry.

3. Currently, the industry's research institutes subordinate to China's ministries and commissions are accepting the mission of product quality inspection and verification entrusted to them by the state. Therefore, this must be an independent and fair agency. If a research institute establishes a close association with a collective in only one area, it will lose its independence and the state will not be able to make a large investment immediately in a newly established inspection agency. However, if the research institute is readjusted and expanded into a development center, it will maintain the inspection center features that the state demands.

III. How is an independent research agency readjusted and expanded? Summarizing the above, electric cable technical development center pilot project findings provide the following:

1. Adhering to the central committee's decision concerning reform of the science and technology system and working hard for approximately five years to shift China's science and technology system onto a new track, we must resolutely and steadily carry out reform practice. In terms of specialized research institutes, which concentrate on technology coverage, readjusting and expanding them to transform them into technical development centers is one of the directions intended by the reform of the organizational structure of science and technology.

2. Technical development centers closely integrate science and technology with the economic development of the industry and serve as the organizers of technical progress as well as independent research and technology units. Therefore, three major science and technology activities will be undertaken: research major science and technology projects and develop and organize attacks on key industry projects (originally a function of research institutes); organize, coordinate, exchange and research demands involving industry commonality, technical services, and administration and management (similar to the functions of the industrial association); inspect, verify, arbitrate, and supervise product quality (a function of the state testing center).

The technical development center is a non-profit unit. It will receive an appropriate share from the results of different types of science and technology activities to cover its day-to-day expenditures. Expenses for major long-range scientific research projects will come from state support for the development of the industry and will use the energy of new technology and the capacity for self-reform. We propose that the state increase the level of enterprise-retained profit to increase the economic power of enterprises to invest in research and development. It goes without saying that this increases the industry's scientific research and development expenses.

3. In order for existing independent research agencies to establish technical development centers with the functions described above, readjustment, expansion, and transformation are required. First of all, the industry must unify economic construction relying on science and technology, and science and technology ideology and understanding oriented toward economic construction, eliminating misunderstandings involving psychology and customs among units in the industry in order for planning to be unified and measures for the industry's technical progress to be implemented. Second, the onerous tasks of the technical development centers undertaken by research institutes should intensify self-construction, improve industrial nature, foresight, and authority, i.e., such areas as ideology and understanding, agencies, personnel organization, technology and testing levels should have the capacity to organize, coordinate, and direct technical work, to forecast and supply the technical development trends and technical reserves demanded by the industry, and to contribute high level service to the industry in terms of technical personnel, scientific research equipment, testing methods, and management level. In other words, the industry intends to accept it as a center, and it will not be isolated and appointed. In this way, reform should be positive, but cannot demand that industry research institutes advance in lockstep on command.

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